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REFINER
AND NATURAL GASOLINE MANUFACTURER

JULY, 1941
Vol. 20, No. 7

A Gulf Publishing Company Publication
EDITED MONTHLY AT HOUSTON, TEXAS

JUL 14 1941

GRADY TRIPLETT
Editor

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SPECIALIZED OIL JOURNALS

Published by
THE GULF PUBLISHING COMPANY

OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *General Manager*
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NEW YORK: Room 625, 250 Park Avenue, Dick Swinsky, Manager.

PITTSBURGH: 72 Vandergrift Building, Chas. A. Wardley, Manager.

CHICAGO: 332 S. Michigan Avenue, H. G. Fitzpatrick, Manager.

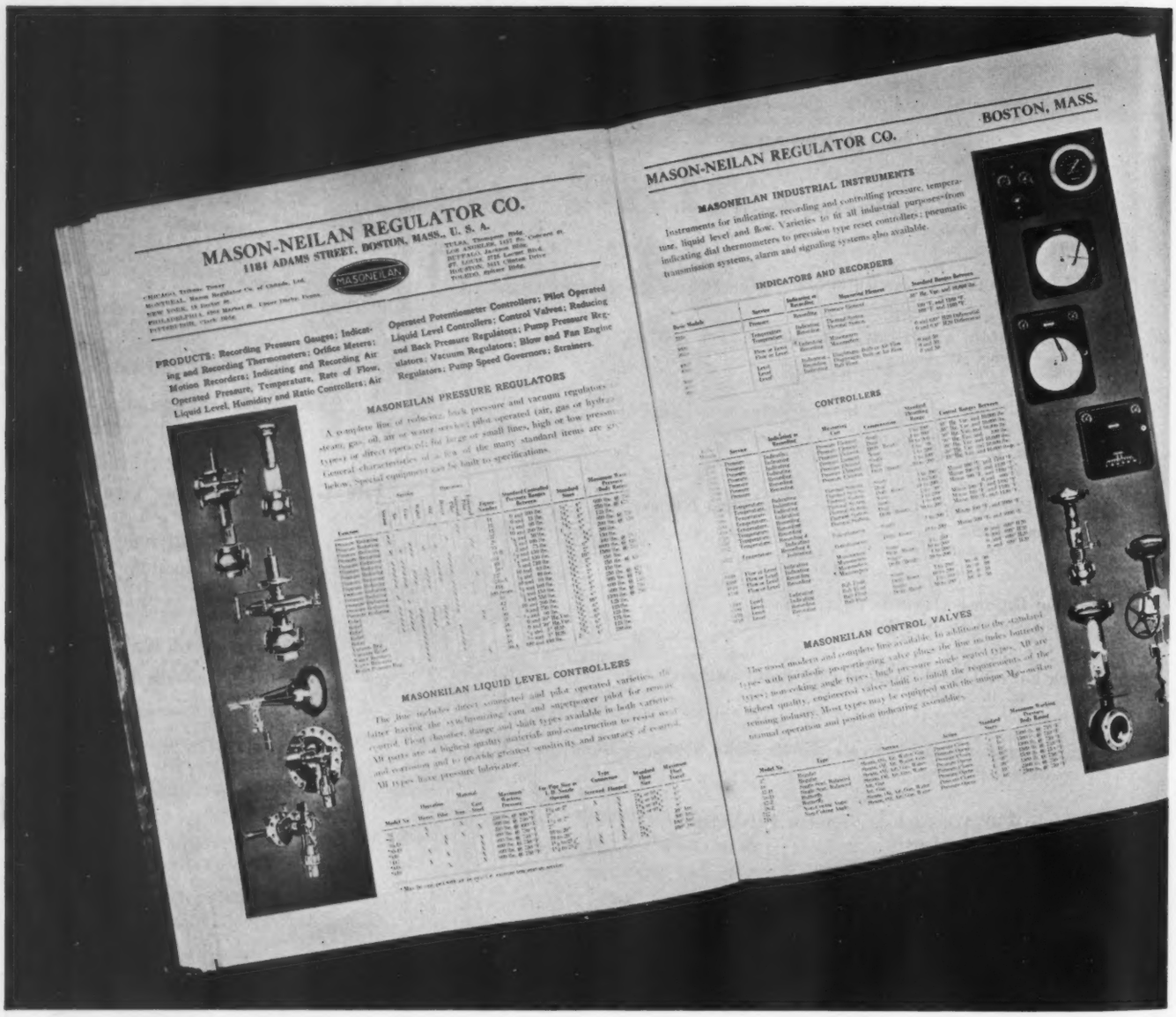
LOS ANGELES: 425 W. W. Wilson Building, Huntington Park, California, Jay Curts, Jr., Manager.

TULSA: 1304 Hunt Building, J. F. Carter, Jr., Manager.

FT. WORTH: 203 W. T. Waggoner Building, H. H. King, Manager.

Single copies 20 cents. Special issues single copies 50 cents. Domestic subscription price $1.00 a year. Canada and Foreign subscription price $2.00 a year. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879. Advertising rates on application. Copyrighted 1941 by The Gulf Publishing Company.

Information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The Look Box

RAPID adoption of oil as a fuel at the expense of coal may be leveling off in the estimate of a study of energy sources in the summer issue of The Index, published by the New York Trust Company. After considering the recent developments whereby diversion of tankers indicated a shift to coal for domestic heating, this estimate of the underlying trend was given:

Sharp Oil Incline May Be Leveling Off

"In 1937 it is estimated that of the total energy consumed in the United States, 45 percent was derived from bituminous coal, 30.4 percent from oil, 9.8 percent from natural gas, 9.3 percent from water power, 5.6 percent from anthracite coal.

"Future demand for oil is closely linked with transportation, whereas bituminous coal, despite its relation to railroad transportation, is more closely associated with metallurgy and the generation of electric power in central states. The growing relative importance of oil as a primary source of energy from 1918 to 1933 was due largely to displacements in transportation, as from railways to highways, rather than to any increasing importance of transportation itself as a source of demand for energy.

"The change-over from rail to highway transport affected chiefly the high-rate, short-haul, less than car-lot traffic. In these lines the change seems to have been completed by 1933, for subsequent gains in relative oil production were shown to correspond with declines in the anthracite coal, reflecting a change to residential heating practices.

"For several years increasingly heavy motor vehicle taxation has offered inducements to economize in motor fuels. The technical quality of the engines has been continually improved and motor vehicle construction shows progress in reducing dead weight. As these designs become more refined, increased amounts of power generated from coal will be required in their fabrication and less oil or gasoline will be needed in their operation."

THIS is a day for writing the record of the petroleum industry in accomplishment. The conference at Washington in June developed nothing startling. Men talked of the tough job ahead of the industry. This was known long before a federal coordinator had been named. It is doubtful that a second or third conference will add much to what the industry knows of its tough job.

Accomplishment Will Stem Control

There is fear of federal control. Few can question of the opportunity that lies in simple coordination, however little officials or industrialists oppose control.

One course away from control is doing the job. There is less chance of control when an industry is on schedule with its tasks. Right now the task is transportation, something the industry knows how to accomplish. If all-out attention is given to that, officials will be busy gaining the legislation that must accompany pipe-line building. Under such conditions, even an ardent control enthusiast

may be busy at doing his part toward accomplishment.

In this period the industry should forget its special and individual favors. The Washington conference produced too many instances of seeking aid to get more sales, different crude oil and assured sources of supply. When an official listens to such a request he is then in the realm of doing a bit of control. Even when the request is denied, it has done its part in establishing conviction that control is needed.

Too many men want assurance in business. They praise competition but seek security. The two cannot exist simultaneously. When government grants favors and balances competitive conditions it is on the high road of control.

Small Capacity But High Cost

AS THE requirements of national defense come to the refining industry it is evident that expansion of plant capacity will be high in cost, although capacity increase may be small. Last month OPM asked for an increase of 25 percent in 100-octane aviation gasoline. That is but 12,000 to 15,000 barrels daily.

In ordinary distillation the cost would be trivial. But equipment required for this gasoline is not ordinary. On small plants it will run at least to $1500 a barrel. Larger installations may cost less.

Synthetic plants for toluol, rubber and other special products likewise are high. Expenditures in 1941 and 1942 promise to surpass any previous year. It is doubtful, however, that total throughput will be increased by the average of 106,000 barrels daily.

Safest Place Is On the Job

FOR THE oil worker it is safer to be at work than at leisure. This is the record of 1940, when fatalities were almost twice as frequent off duty as they were for working time. The figures were compiled by the Department of Accident Prevention, American Petroleum Institute.

The 1940 fatal-injury record for the industry was the lowest since the report has been compiled. Reports on 327,112 workmen showed but 101 fatal accidents, a ratio of 30.9 per 100,000. The rate per 100,000 for those reporting both industrially and off-duty fatalities was 28.3 while on duty, compared with 48.3 while off duty.

Causes of fatal accidents for the year were: fires and explosions, 36 percent; motor vehicle operation, 17 percent; asphyxiation, 5 percent; miscellaneous, such as falls, falling objects and drowning, 38 percent.

Revise Ideas on Needed Stocks

ALTHOUGH the oil industry normally has been concerned with too much, rather than too little, of crude oil and refined products in storage, it now faces an extraordinary situation in which ideas on proper stocks will have to be tempered with recognition of the desirability of extra inventories to take care of contingencies, as attested by the situation that has developed suddenly out of the unexpected diversion of tankers to British service.

The problem of supplying the East Coast would be less difficult, if inventories of all oils had been maintained at higher levels in that region. Moreover, the problem would be easier to solve if stocks had been larger heretofore in the Applachian region, in the Middle West, and in the Upper Mid-Continent, as supplies in those areas might have been used to alleviate the threatened scarcity in the Eastern consuming region.

The industry naturally has been put on guard, through the present difficulties, against avoidable shortages of products on the Atlantic seaboard and in the Middle West in the future. Refinery runs have been stepped up to unprecedented levels, and in the week ended June 28, when a new high of 3,930,000 barrels daily was reached, plants were operating very close to capacity in the East Coast, Appalachian, Mid-Western, Mid-Continent, and Gulf Coast districts, and for the country as a whole, about 92 per cent of rated refinery capacity was being utilized.

However, subsequent developments may show that this near-capacity refining has been reached tardily; and even the present prospects indicate that exceptionally heavy runs to stills will be necessary throughout the summer, and in fact indefinitely, to meet prevailing and prospective record-breaking demand.

Meanwhile, stocks of all the major products are moderate in relation to the trends of demand. Measured in terms of days' supply at prevailing rates of consumption, stocks of gasoline and of lubricants are smaller than in either of the past three years and about the same as in 1937. Stocks of heavy fuel oil are much smaller now than in recent years, in relation to demand. Inventories of light fuel oils and kerosene are more ample than in other recent years but are moderate.

In these circumstances, it is indicated that there is not even any remote danger of accumulation of substantial excesses of products in storage. On the contrary, the principal threat, apparently, is that of allowing stocks to become too small in relation to market requirements.

Stress-Relieving Welded Pressure Vessels in the Field

E. S. ROBB
Deer Park Refinery, Shell Oil Company, Inc.

DUE to operating conditions, extensive welding repairs, or additional heavy welding occasioned by the installation of new nozzles, manways or reinforcing pads, it may be necessary or at least desirable to stress-relieve a part or the complete welded vessel. It has been found practical and much more economical to do the work in the field rather than to dismantle the unit and send the vessel back to the manufacturer. An outline of the equipment and methods used together with the results obtained is discussed in this article.

MOHAMMED was right. By the same token that he found it was more practical to go to the mountain than to have the mountain brought to him, it has proven to be more practical and economical to stress-relieve existing welded pressure vessels in the field, by applying heat directly within the vessels themselves and without removing them from their foundations, than to dismantle the unit and send the vessels to the heat-treating furnace at the fabricator's shops.

Stress-relieving of existing welded vessels may be necessary, or at least desirable, because of, first, previous operating conditions which set up internal strains in the metal due to sudden temperature changes; second, extensive repairs to welded seams or nozzle connections; third, additional heavy welding occasioned by the addition of new nozzles, manways or reinforcing pads, and fourth, possible salvaging by major repairs or revisions that can be done in the field.

The necessity or desirability for stress-relieving is a question best answered by the local engineers and those of the manufacturer. The fact, that stress-relieving in many cases may be done without the vessels being moved from their foundations, may be the deciding factor and is therefore of practical and economical importance. Not only is there a large saving in direct costs with this method but several weeks of operating time may be saved and this is often the most important consideration.

The stress-relieving temperature generally used for low-carbon steel is between 1100° F. and 1200° F. The soaking time required at this temperature is one hour per inch of wall thickness as a minimum. Since extra soaking time may be desirable, a more conservative rule is to add the thickness of the heaviest reinforcing plate to the wall thickness and allow one hour per inch of total thickness.

The rate of heating above 600° F. should not exceed 400° F. per hour divided by the maximum metal thickness of the shell or head plate, and it is desirable not to exceed these rates at temperatures below 600° F. The rate of cooling above 600° F. should not exceed 500° F. per hour divided by the maximum metal thickness of the vessel in inches. The temperature gradient in the metal of the chamber should not exceed 250° F. within any 15 feet of lineal distance during the heating period and the whole vessel should be within 150° F. during the soaking period.

The above limitations of temperature and of the heating and cooling rates are specified in the "API-ASME Code for Unfired Pressure Vessels," section W-462.

In the last 3½ years, Shell Oil Company has found it desirable to completely stress-relieve several 10 feet x 40 feet wall coking chambers with 2-inch wall, and the top head only of one 6 feet x 48 feet wall reaction chamber with 3⅞-inch wall. Since the stress-relieving of a complete chamber is a different problem from doing a part of a chamber, the two methods will be described separately.

Stress-Relieving a Complete Chamber

The vessels, which were completely stress relieved, were 10 feet in diameter, 40 feet high and had a nominal wall thickness of 2 inches. The vessels were electric welded throughout and were equipped with 24-inch diameter manways in the top and bottom heads. In addition, three nozzles up to 8-inch in size were welded in the top head and one 2-inch in the bottom head. There were no trays, pans or other obstructions on the inside of the vessels. Each vessel was supported on a circular steel cradle which was supported by a concrete foundation. The bottom of each vessel was approximately 12 feet above the ground level.

The vessel to be stress-relieved was completely blinded off from the remainder of the unit and all lines were disconnected from the chamber so that the expansion during the heating cycle would not distort the piping or nozzles. The top housing and platform plates were removed and the top head thus exposed was completely covered with bulk insulation. All nozzles and manways were heavily insulated to prevent any sharp temperature differentials.

The outside insulated housing surrounding the vessel was left intact and with this protection it was found that the temperature gradient across the 2-inch wall did not exceed 15° F.

The protective ganister lining on the inside of the vessel was removed completely; the walls sand-

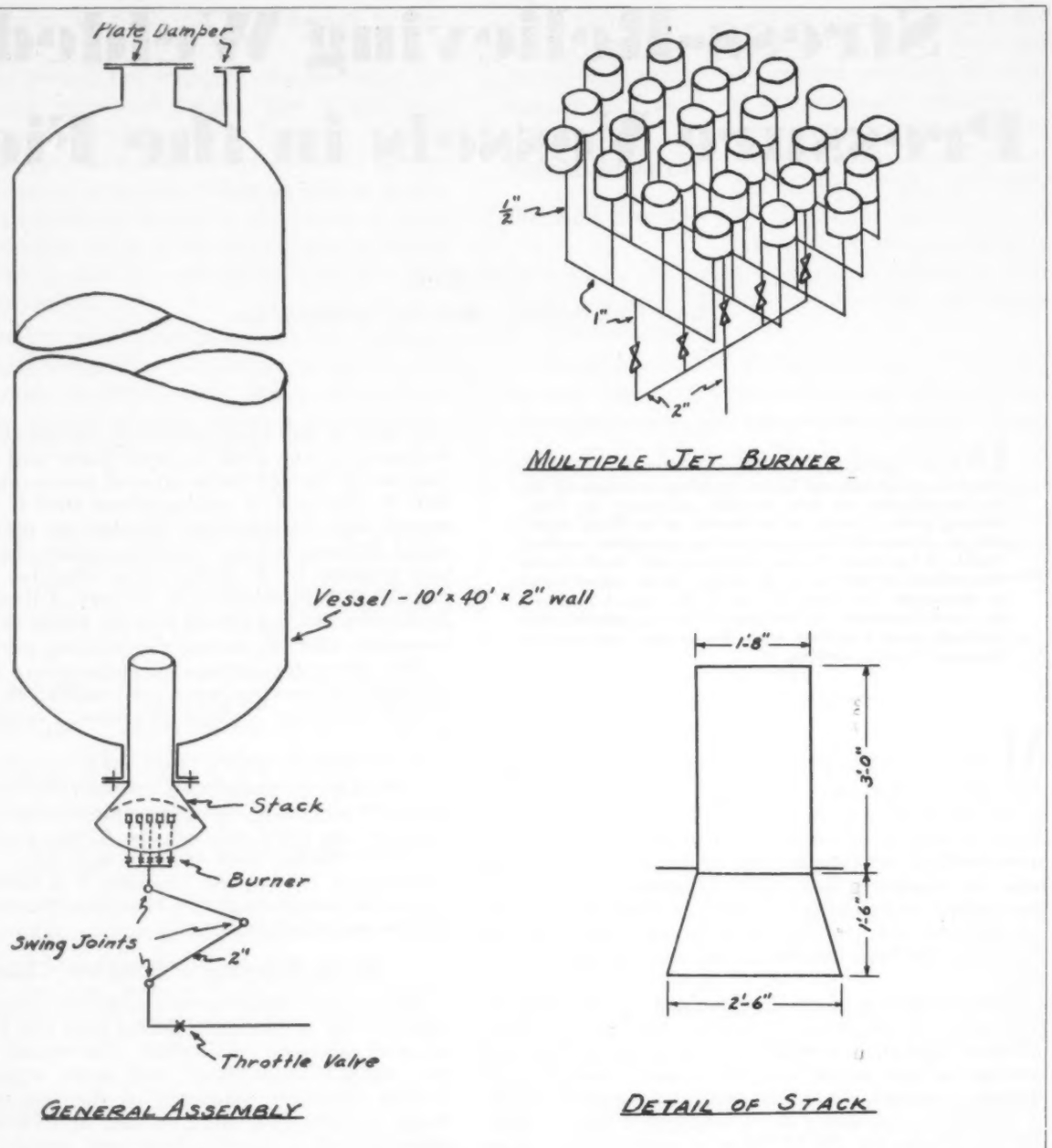


FIGURE 1

Burner arrangement and details for stress relieving a complete chamber

blasted, inspected and repaired where necessary. All pressure-relief valves were removed and all nozzles on the top head were opened.

The assembly of the burner arrangement for heating the vessel is shown on Figure 1. A steel stack, 20 inches in diameter, 3 feet long and with a flared skirt on the bottom end, was fabricated from salvage pipe and installed as shown. This stack was inserted through the bottom manway and bolted to the manway flange. The top of the stack projected in the chamber approximately 2 feet.

A multiple-tip gas burner was suspended by long bolts within the flared end of the stack. By means of the bolts, the burner could be adjusted up or down to vary the amount of primary air drawn through the burner and the amount of secondary air drawn in over the top of the burner.

The burner was made from 24 venturi-type tips which were assembled on 5 headers with individual block valves for each header. This arrangement gave a relatively short clean flame. The piping to the burner was installed with double ells to provide flexibility in adjusting the position of the burner. A regulating valve in the supply line gave a constant gas pressure to the burner.

Temperature Control

Since it had been found that the temperature gradients across the 2-inch wall were small, thermocouples were installed on the outside of the shell only. The couples were inserted in shallow drilled holes and the metal thoroughly peened down to insure accurate temperature readings. A recorder was used to log the temperatures throughout the com-

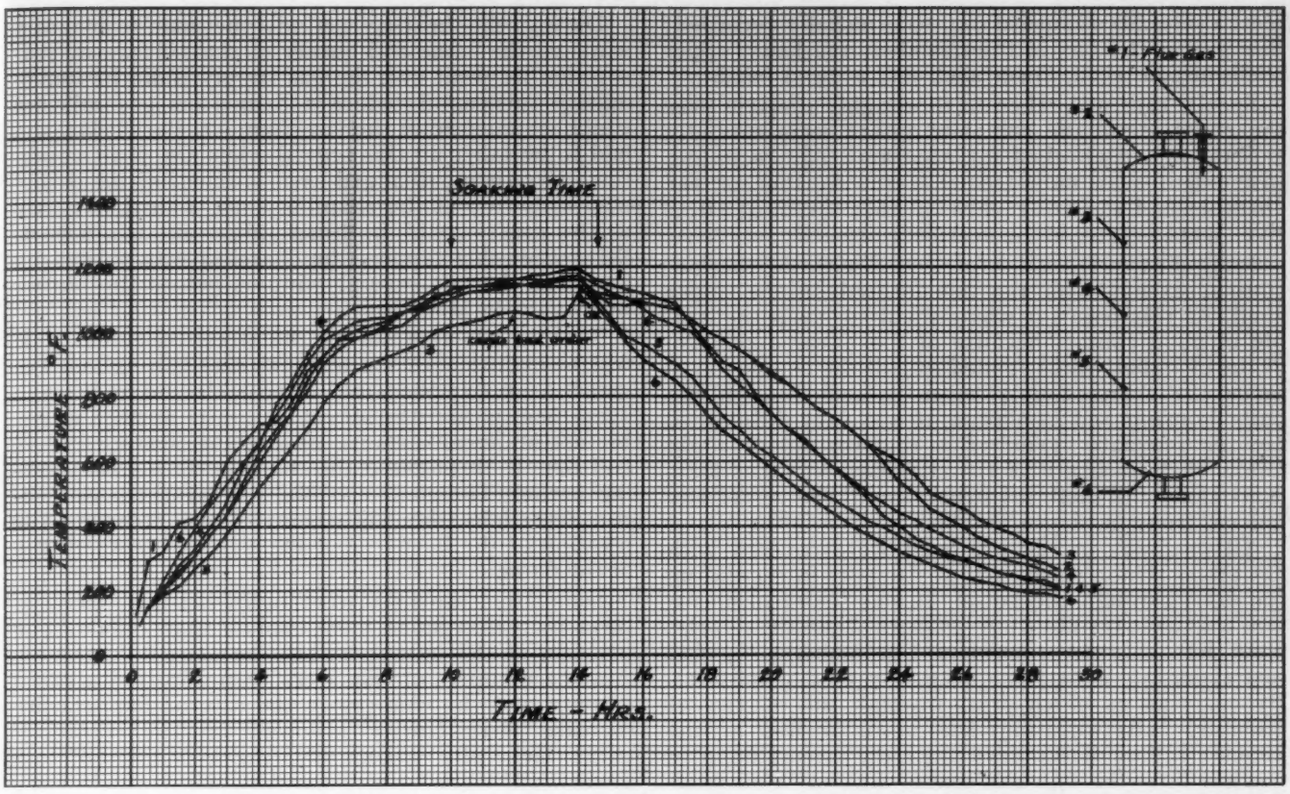


FIGURE 2

Recorded temperatures in stress relieving a coking chamber, 10 x 40 feet with 2-inch wall

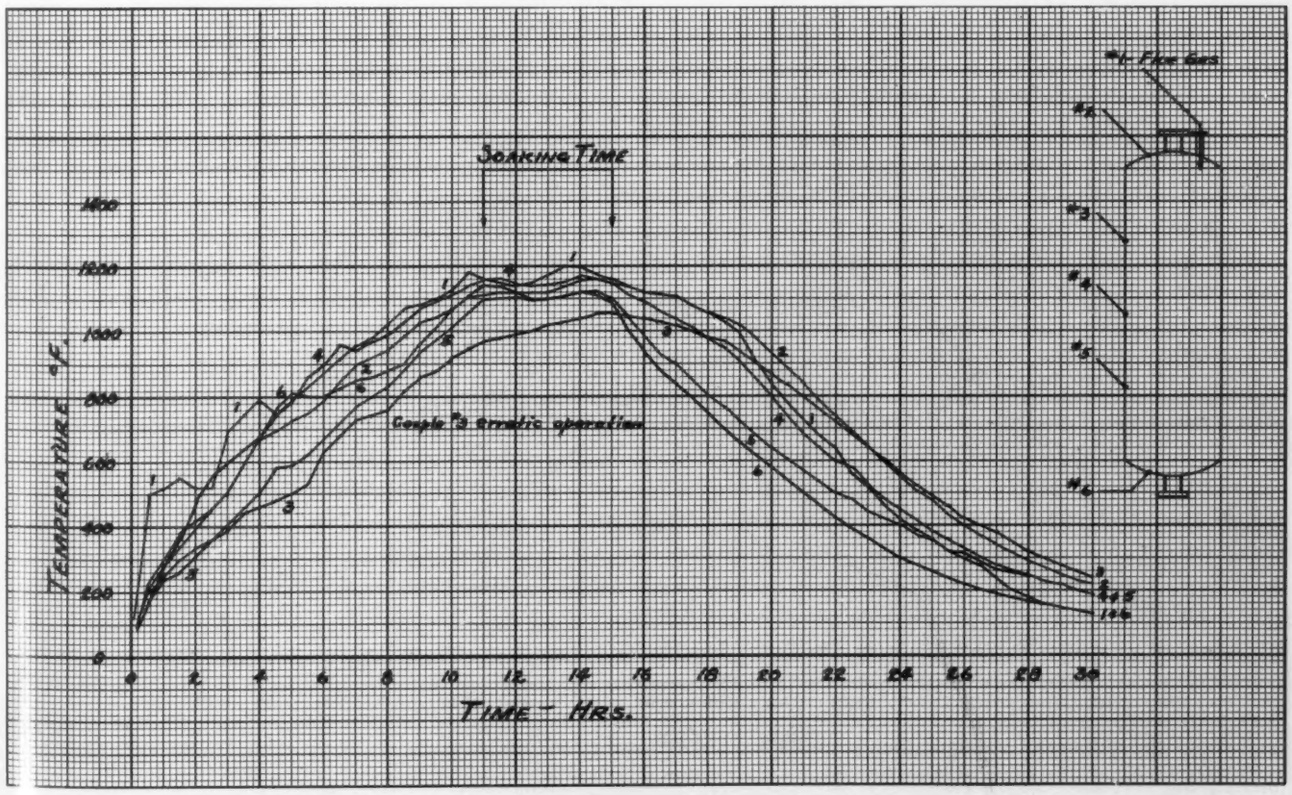


FIGURE 3

Recorded temperatures in stress relieving another coking chamber, 10 x 40 feet with 2-inch wall

plete cycle. Six temperatures were usually recorded; flue gas at the top of the chamber, top head, upper shell, middle shell, lower shell and bottom head.

Special care was taken to thoroughly insulate over the couples and the complete system was carefully calibrated and checked for accuracy. The recording instrument was mounted near the bottom of the chamber and the firing valve so that the most effective operation could be realized.

No great trouble was experienced with the thermocouples except with the one located on the upper shell. At this point, it was difficult to keep the couple in good contact because of the linear expansion of the chamber which tended to pull the couple loose. Since the thermocouple wires passed through the outer housing and insulation, it was very difficult to provide adequate flexibility so that the couple could follow the movement of the chamber. At other locations along the shell, the expansion of the vessel was not sufficient to cause trouble.

All openings in the top head were covered with flat plates which were used as dampers in regulating the draft through the vessel. It was found in operation that best results were obtained when the nozzles were left entirely open and the manway opened just enough to satisfy the necessary draft conditions. By carrying as much draft through the nozzles as possible, better heating was accomplished at the knuckle radius of the head since the streamlining of the gas flow through the center manway was minimized.

The crew consisted of two men per shift. Each crew leader was experienced in the characteristics of gas flames and was carefully picked by his previous workmanship, judgment and initiative.

During the heating period, one man constantly watched the flame and burner so that, if for any reason the fire went out, the gas supply could be immediately turned off before a dangerous gas mixture could accumulate in the hot chamber. Particular care had to be taken in this regard when the draft conditions were being changed by movement of the dampers on the top of the chamber since a small increase in the draft would, at times, blow out the burner. When this did happen, the chamber was purged by the natural draft several minutes before the burner was again lighted.

The big problem during the stress-relieving cycle was to maintain all the temperatures throughout the vessel as nearly the same as possible and at least to keep them within the allowable limits of 250° F. per 15 feet of lineal distance during the heating period and 150° F. throughout the chamber during the soaking period. The control of the temperatures was accomplished by the adjustment of the dampers, the position of the burner, and the size and temperature of the flame.

Soon after the fires were lighted, some temperatures increased much more rapidly than others. The position of the burner within the skirt of the stack and the dampers on top were then adjusted a small amount and the changes in the rate of temperature increase were closely followed on the recording chart. Generally speaking, if the bottom head and lower shell were heating too fast, the dampers were opened to give more draft and, if necessary, the burner lowered to give more secondary air in order to cool the stack and carry more heat to the top head and upper shell. If the top head and upper shell were heating too fast, the dampers were closed in order

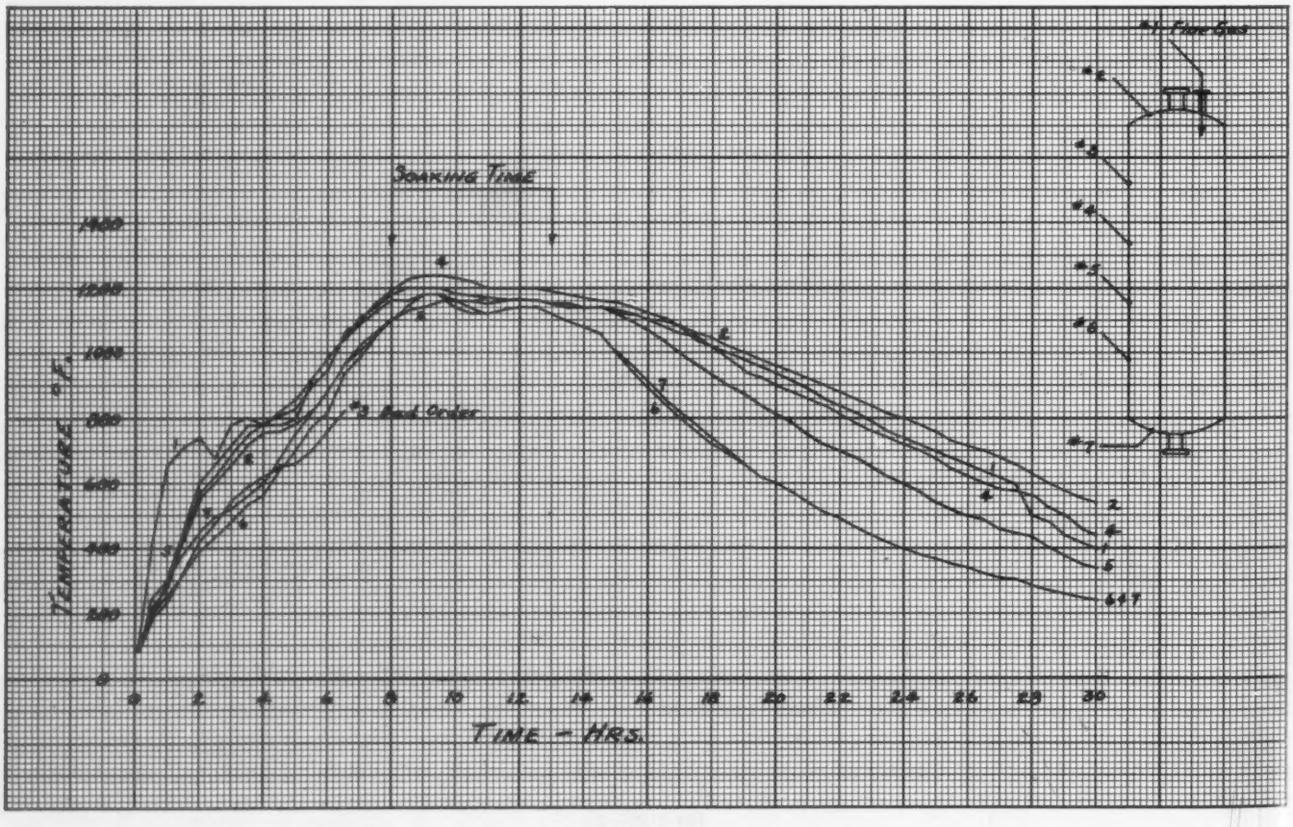


FIGURE 4

Recorded temperatures in stress relieving a coking chamber, 10 x 40 feet, with 2-inch wall

to hold the heat down. Very often, only one adjustment was made at a time, either the dampers, the burner position or the firing valve being changed.

Although all chambers were of the same size and equally insulated, the burner and damper settings for one vessel did not give satisfactory results for another chamber. This was probably due to the wind velocity, wind direction, atmospheric temperature and relative humidity being different which affected the draft and other characteristics of the heat transfer.

The bottom head and lower shell received their heat by radiation from the stack section within the chamber. The amount of primary and secondary air used, the amount of gas burned and flame temperature determined the temperature of the stack section which in turn determined the amount of radiation to the vessel walls.

Figures 2, 3, and 4 show the metal temperatures as recorded during the stress-relieving cycles for three different chambers.

Figure 5 shows the metal temperatures for the first vessel that was stress relieved. As it developed, this chamber made a good "guinea-pig" for future work. It will be noted that all of the temperatures were never brought within the soaking range at the same time.

With this chamber, the burner was placed in the straight section of the stack, not in the skirt, and it was found impossible to bring the upper part of the vessel to the desired temperature without getting the lower part too hot. Two pressure burners, fabricated from pipe and fittings and using the plant air supply with the gas, were inserted through the top manway in order to give additional heat to the upper part of the vessel.

It was found, however, that the lower burner had to be cut back to reduce the draft in order to keep the upper burners lighted. After cutting the lower burner, the temperature in the lower part of the chamber fell off and, while the upper part of the chamber came up to the stress-relieving temperature with the pressure burners, it was not possible to increase the lower burner due to the limitations on the draft.

After this experience, all other chambers were stress-relieved with the burner in the flared end of the stack so that better adjustment of the primary and secondary air as well as the temperature of the stack could be controlled. With the burner in this position, satisfactory operation was realized.

An inspection on the inside of the vessels was made after they cooled and also on the outside of the top heads. This inspection revealed only a very light film of oxidation on the surface of the metal and no additional defects were found in any of the welded seams, nozzles or reinforcing pads.

Stress-Relieving Top Head of Chamber

In stress-relieving only a part of a vessel, the same rates of heating and cooling and the same soaking time as for stress-relieving a complete chamber are applicable. Additional limitations are necessary, however, in that a maximum temperature gradient of

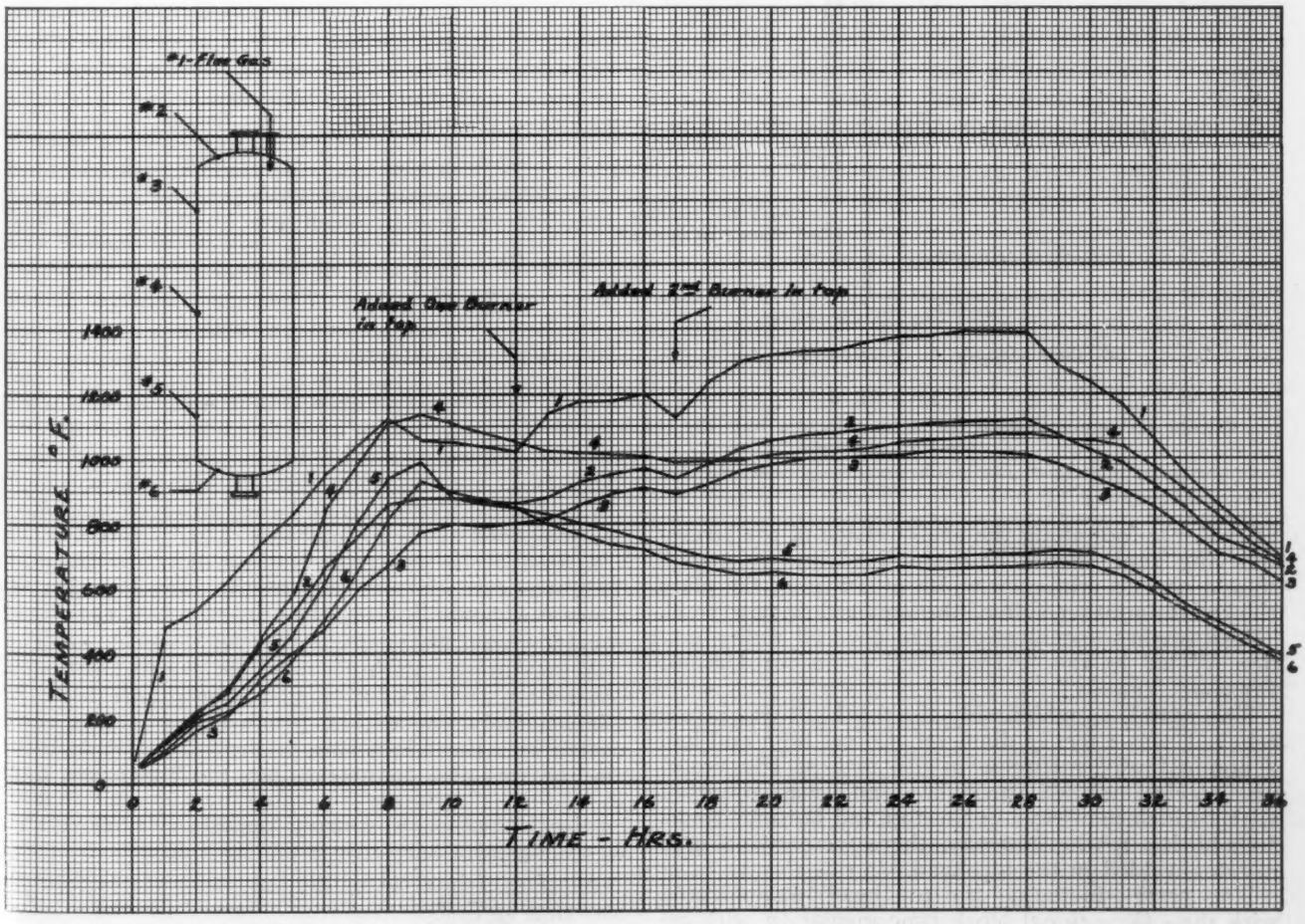


FIGURE 5
Recorded temperatures in stress relieving a coking chamber, 10 x 40 feet, with 2-inch wall

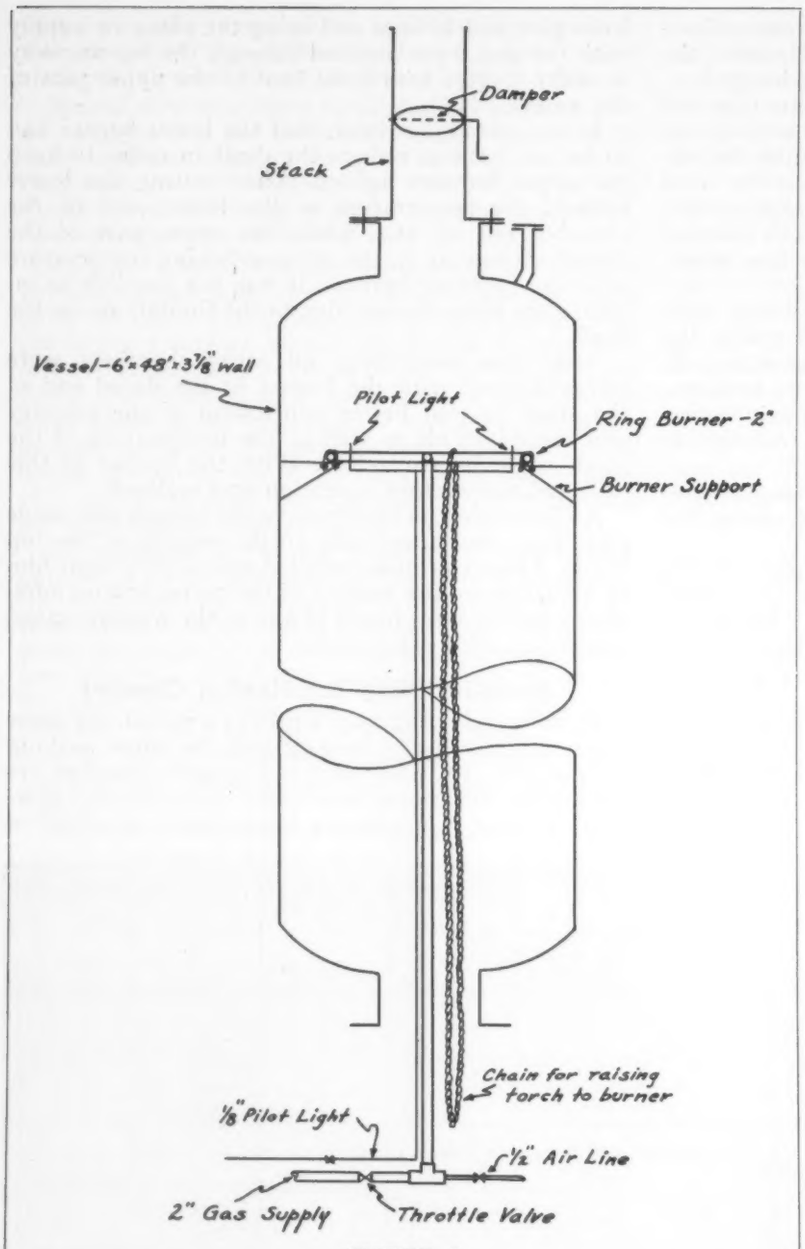


FIGURE 6
Burner arrangement used for stress relieving only the top head of a reaction chamber.

200° F. per foot along the shell outside of the stress-relieving zone should be maintained and this zone should cover a minimum width of six times the plate thickness on either side of the repaired or new weld. These further specifications are covered under section W-462 in the "API-ASME Code for Unfired Pressure Vessels."

The vessel, on which only the top head was stress relieved, was 6 feet in diameter, 48 feet high and had a nominal wall thickness of 3⅞ inches. The vessel was electric welded throughout and was equipped with 24-inch manways in the top and bottom heads. In addition to the manway, there were two 4-inch nozzles welded in the top head.

The vessel, including the top head, was covered with the conventional block type insulation with reinforcing wire and weather-coating. The vessel was without obstructions on the inside. It was mounted on a concrete foundation with its bottom head approximately 12 feet from the ground. Figure 6 shows the arrangement of this chamber together with the equipment used for stress-relieving.

All lines were disconnected from the top of the vessel and all others were blinded off. The protective ganister lining installed on the inside of the vessel was removed from the top head and for a distance of 10 feet down the side walls. All nozzles and the manway on the top head were heavily insulated and the nozzles covered with plate blinds.

A steel stack, approximately 8 feet high, was fabricated from light weight 18-inch pipe. A plate ring was welded to one end of the stack and by this means the stack was bolted to the flange of the top manway. A damper was installed inside of the stack in order to regulate the draft. The damper handle was so arranged that it could be locked in any position.

Burner Arrangement

The burner was fabricated from 2-inch standard pipe and was of the simple ring-type design approximately 4 feet in diameter. The ring was made in halves with one cross member in the middle. Suitable screwed unions were used, which made it easy to assemble the burner inside the chamber. A 2-inch gas supply line from the bottom connected into the center of the burner. The ring was supported on welded braces from the chamber wall located approximately 8 feet below the tangent line between the shell and the top head. Care was taken to mount the burner in the center of the chamber. Forty-two 3/16-inch diameter holes were drilled in the ring and cross member.

A pilot line, ⅛-inch pipe, was wired to the 2-inch supply line and two pilot lights on opposite sides of the burner were supplied from this source. A continuous light-weight brass chain, which looped around the burner cross member, extended to the ground level and by this means, a lighted torch was pulled up to light the burner. This was essential not only at the start but also as a means of again lighting the burner in case the flame was blown out after stress-relieving started.

A pressure-regulating valve held the fuel gas at a constant pressure of 22 pounds per square inch. A 1-inch supply line with a 1-inch throttle valve connected into the 2-inch line to the burner. A ½-inch air line was also connected into the 2-inch gas line so additional primary air could be supplied to the burner if necessary. During operation, however, it was never necessary to use the air line.

A point of interest in the operation of the burner was that sufficient heat was obtained for the stress-relieving with the 1-inch throttle valve in the gas line open only about three quarters of one turn and

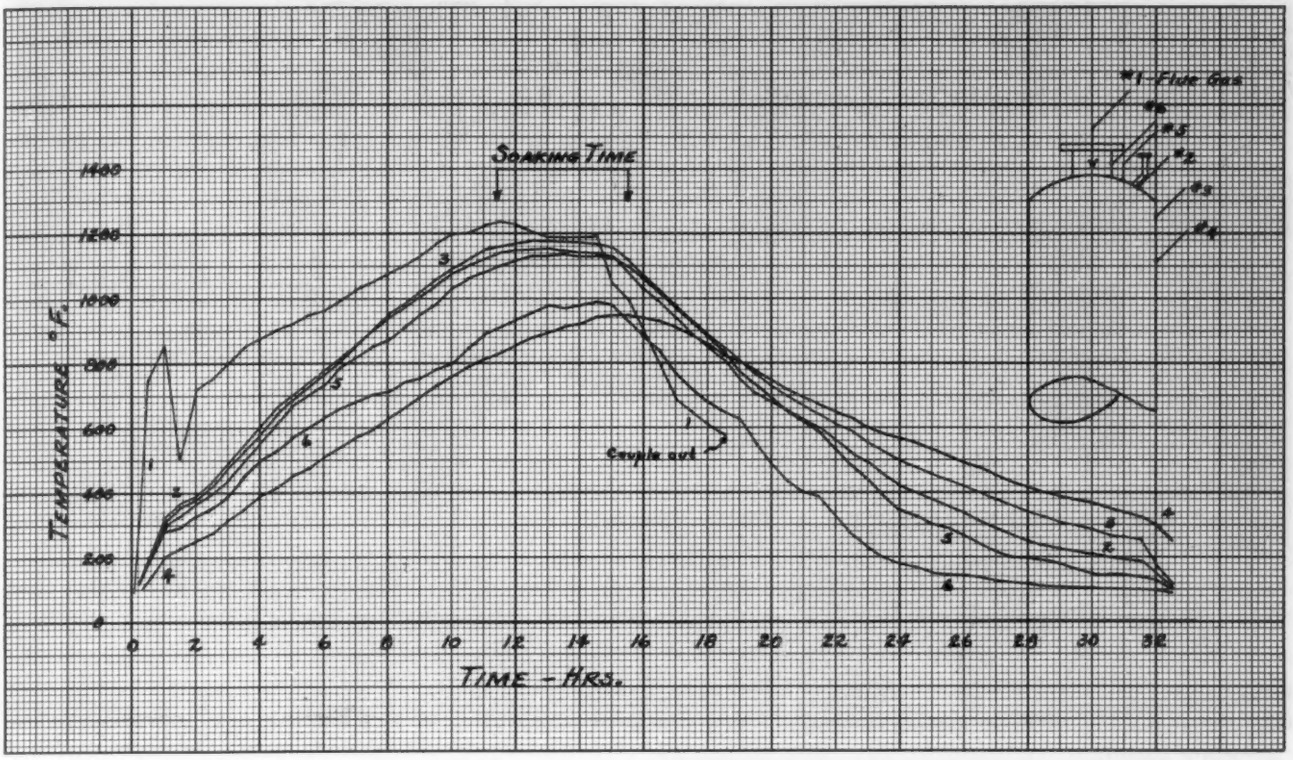


FIGURE 7

Recorded temperatures in stress relieving top head of a reaction chamber, 6 x 48 feet, with 3⅞-inch wall

with the ⅛-inch valve in the pilot line open only about two turns. This was much less than expected and a fewer number of holes in the ring burner and of smaller size would have been advantageous.

The locations of the temperature readings are shown on Figure 7. Couple Number 1 recorded the gas temperature in the manway neck; couple Number 2 the metal temperature at one of the 4-inch nozzles; couple Number 3 the metal temperature 2 feet down the head from couple Number 2, couple Number 4 the metal temperature 2 feet down the shell from couple Number 3; couple Number 5 the metal temperature 1½ feet from the above nozzle toward the manway, and couple Number 6 the metal temperature in the manway neck. All temperatures were taken on the outside of the vessel with the thermocouples well peened in shallow holes drilled in the metal. The location of couple Number 2 was at the center of the stress-relieving zone and the location of couple Number 3 was at the lower limit of this zone.

Figure 7 also shows the recorded temperatures throughout the stress-relieving cycle. By careful adjustment of the stack damper and the firing valve, it was possible to keep the temperatures within the specified limits. Care was taken also in adjusting the flame that it did not impinge on the metal of the top head.

The same precautions in operation as used in stress-relieving a complete chamber were followed. The burner gave a rather yellow flame but not a smoky one. Due to the relatively small draft through the chamber, no great difficulties were encountered in keeping the burner lighted.

An inspection of the head after the stress-relieving showed the metal in good condition with only a slight oxide scale on the surface. No additional defects were found.

In general, this was a much easier operation than stress-relieving a complete chamber.

Items of Special Importance

In summary, several points were found of particular importance in all field stress-relieving work and these are set out here for special attention of those who may contemplate similar work:

1. Select the operating personnel carefully and give them a complete picture of what is desired.

2. Do not attempt to log the temperatures manually. Use a recording instrument. This not only gives a permanent record but is of great help to the operator in following the rates of temperature increase or decrease.

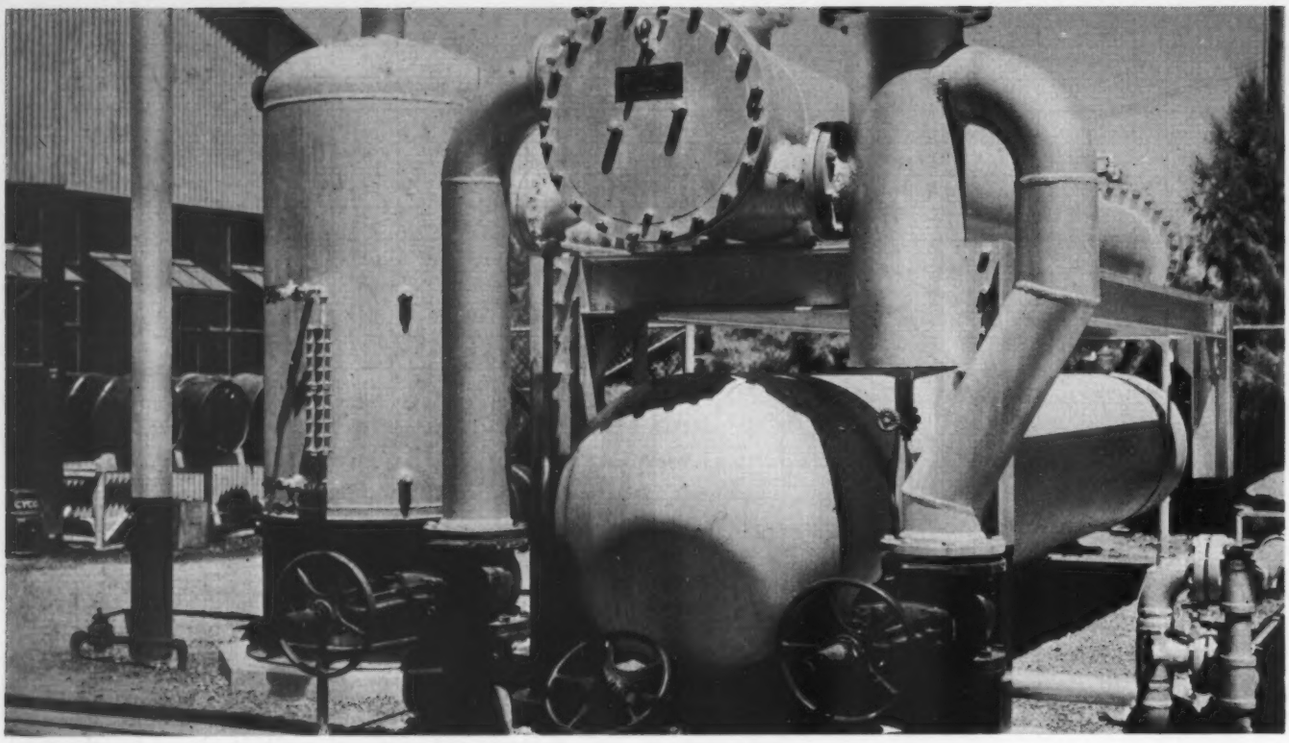
3. Use a good pressure-regulating valve in the gas supply line. This is most necessary for smooth operation.

4. Do not sacrifice the limits of temperature change for speed in completing the stress-relieving cycle.

5. Let the natural draft purge the vessel should the burner be blown out. Do not purge with steam.

6. After making a change in the burner setting, draft or firing valve, wait a sufficient time for the temperature trend to be well established before making a second change.

7. Be sure that the flame does not impinge on the metal surface.



End view of propane condenser above accumulator tank; scrubber at left

Refrigeration Aids In Iso-Butane Manufacture

BY ADDING propane refrigeration units for the lean oil and the field gas circuits and redesigning tower equipment, Superior Oil Company of California has provided output of iso-butane and increased production of normal butane and stabilized natural gasoline in its Kettleman Hills plant. The iso-butane output is being used as feed stock for the manufacture of 100-octane gasoline in refining.

Constant temperatures are essential to butane production, and weather conditions in the Kettleman Hills area are such that only chilling will assure this. The area has relatively low humidity except in the rainy season. Lack of sufficient wind velocity during parts of the day throws a load on atmospheric cooling that is difficult to overcome in towers.

Absorption oil and field gas are handled in the chilling system under average pressures of 450 pounds. The units were designed to reduce the temperature of 390,000 gallons of absorption oil daily from 95° F. to 70° F. and a reduction from 90°F. to 70° F. on 50,000,000 cubic feet of gas daily. The higher temperatures in each case are average accomplishments by atmospheric cooling under conditions prevailing at Kettleman Hills.

Compression for the propane-chilling medium is provided through one four-cycle, six-cylinder gas engine, connected to three horizontal gas-compression cylinders.

Upstream in the vapor line to the compression cylinders is a scrubber to trap liquids and prevent their entry into suction. Downstream from the discharge header is a second scrubber to trap lubricants that carry over with hot propane vapors. This scrubber is connected to a horizontal shell-and-tube water-cooled propane condenser. Below this condenser and in the same supporting structure is a horizontal propane surge tank, followed by a series of tubular water-cooled propane subcoolers.

The propane liquid line leads to the four high-pressure absorbers, near which are the two chilling units. Each is an insulated shell-and-tube exchanger, equipped with instruments for control of both liquid level and pressure. The unit for the field gas is between the atmospheric cooling sections and the absorber-gas-inlet connections. The oil chilling unit takes its charge after the absorption oil has been through conventional cooling.

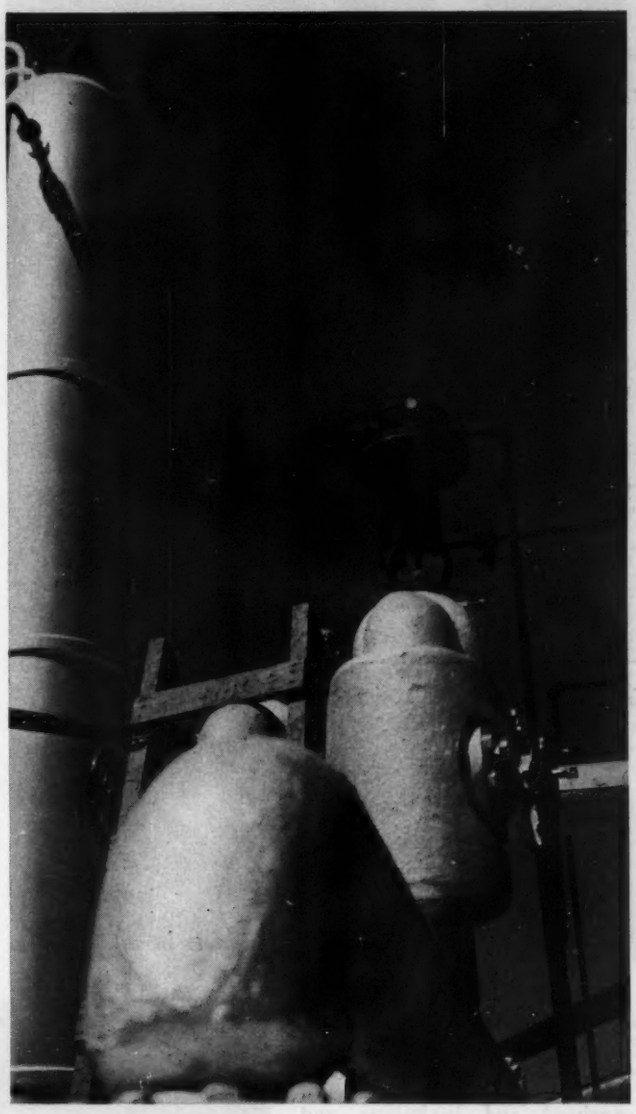
Both chilling units are tied into the operating system in parallel with the old installation of piping, having control and block valves so the plant can be

operated either with or without refrigeration. Gas flows from the atmospheric coolers to a header behind the absorbers, where it is by-passed into a second header, for diversion into the propane chiller. Outlet lines from the chiller are tied into the old system so the cold gas enters the towers through original connections. The oil circuit is so connected to the existing equipment that control valves permit each absorber to be operated with equal volumes of oil.

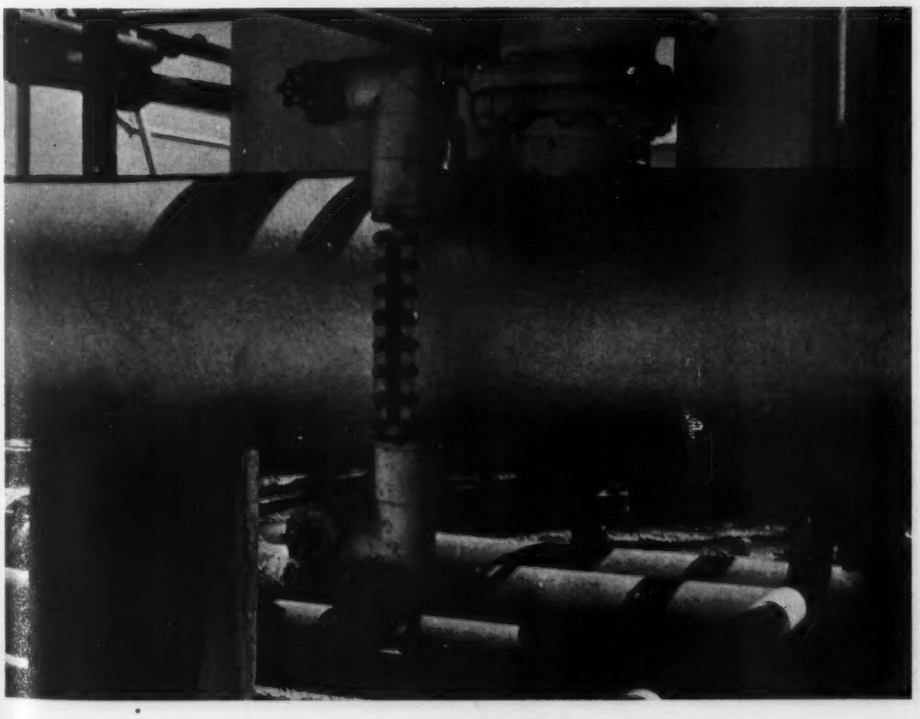
Operation of the units is based on control of pressures within shells of the chillers. Temperatures of both oil and gas are variable, often mounting to as high as 100° F., consequently the quantity of propane fed to the units must be adjusted to meet the requirement of maintaining required temperatures at the output of the units. A pressure of 100 pounds has been found adequate for holding temperature of the output gas at 60° F. Pressure on the lean oil unit is held at 80 pounds, to maintain the oil temperature at 65° F. before it enters the absorbers.

Varying temperatures of these products as they enter the chillers accordingly calls for variation in the amount of propane fed to the unit for evaporation. Liquid-level controls govern this function of the refrigeration system. Determination of the proper liquid level was found by trial and error. This resulted in a point three fourths full being selected. This level provides a flooded condition for the majority of the tubes. Below half full excessive chilling in the upper tubes of the gas unit resulted in formation of hydrates and consequent plugging of the system. A level higher than three fourths brought violent ebullition at the surface and consequent carry-over of liquid to the compressor.

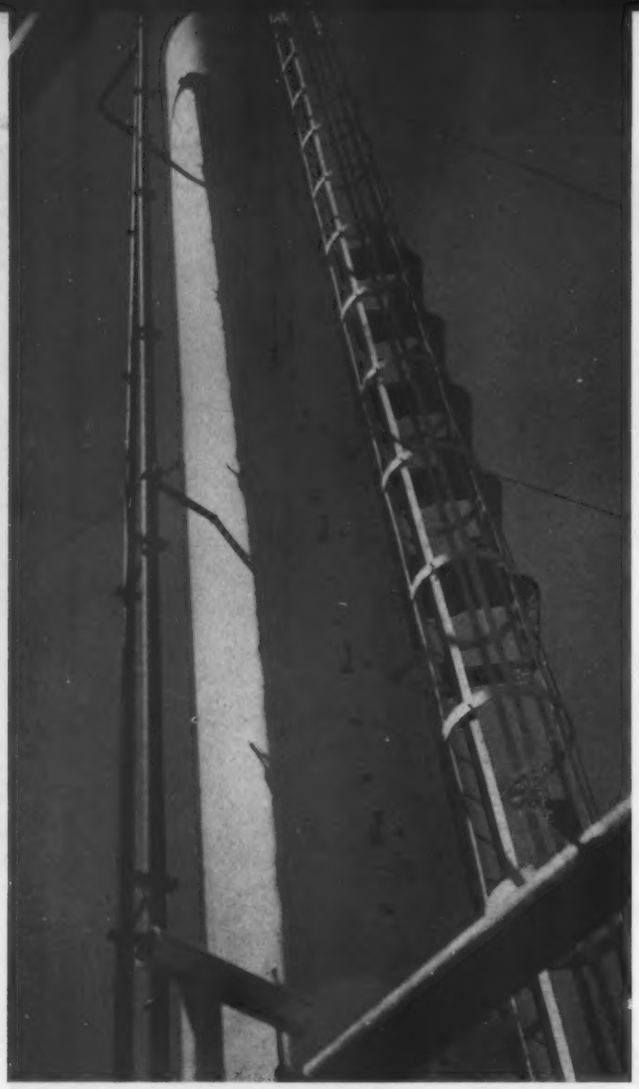
The quantity of propane vapors fed to the system to meet the refrigeration required for changes in temperature of products is provided by two methods. Compressor cylinders are provided with clearance pockets with hand-wheel adjustments. If low capacity at this point is not sufficient to reduce compression, speed of the engine is adjusted downward. With



Top of lean-oil chiller with instrument maintaining constant pressure on the propane refrigerant.



Gauge on side of shell-and-tube unit, to indicate level of liquid propane in chilling unit.



Showing thermometer well connection for tower control, located at side of ladder above top inlet nozzle, so that relatively pure propane can be recovered overhead and iso-butane and higher boiling fractions remaining in column and withdrawn at base.

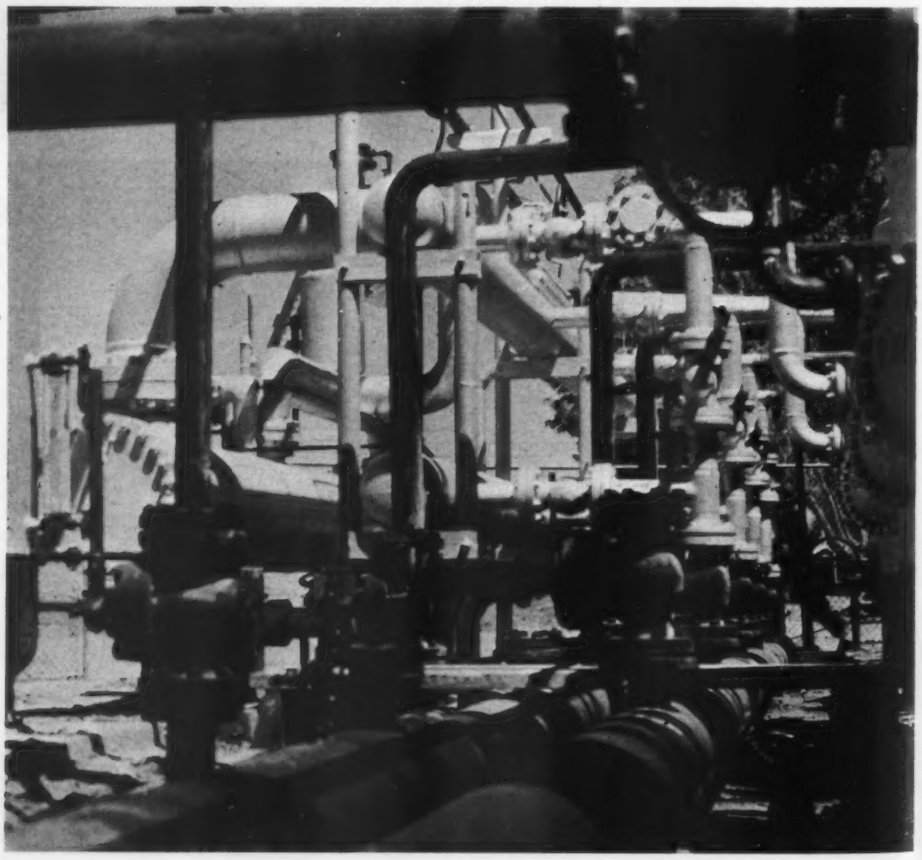
higher temperatures to overcome, cylinders are set at full capacity and engine speed fixed to meet requirements.

In redesigning the plant to take advantage of refrigeration, most of the towers were left in place but some were shifted to new duties. The four absorbers were left to that duty. The stabilizer column, however, was converted into a depropanizer by addition of more inlet nozzles. In this service it has 5 inlet nozzles, 50 bubble trays and an outside reboiler. The 5 nozzles for feeding raw gasoline are between the fifteenth and twenty-seventh trays, counting from the base.

It is operated at 240 pounds pressure. The charge is raw gasoline from the distillation units plus recompressor condensate. The two are mixed on the discharge side of the charge pump. Variation in proportions of raw gasoline and low-boiling fractions, due to changes in atmospheric temperature, make it impossible to have a combined charge of constant composition.

As the function of the first column is to remove only propane and lighter cuts, the column control point is at the thirtieth tray rather than at the vapor outlet above the top plate. This operation allows sufficient tray space for fractionating the propane when the feed varies widely in composition. Trays above this control point compensate for any lag in pumps or instruments without degrading either product with heavier material overhead or propane in the base liquid.

Temperature of both the reboiler and the thirtieth plage, 273° F., is controlled by one instrument. With a reflux ration of 2.5:1 the overhead temperature varies between 105° F. and 110° F. The overhead product is relatively pure propane with ethane. The



Behind the high pressure absorbers, showing chiller in left background, and arrangement of piping for control of flow.

overhead product is pumped back over the column as reflux and the excess goes to pressure storage.

Output at the base of the depropanizer by liquid-level control is fed to the second fractionator, the debutanizer. This second column produces natural gasoline, usually 21.9 Reid vapor pressure at the base with both normal and iso-butane overhead. Material is fed to this second column automatically since it is operated at only 94 pounds pressure. Reflux ratio on this column is 2.5:1. The excess over the amount needed for temperature control goes to a third special column, which is operated to accomplish exact separation between iso- and n-butane.

This column, 85 x 4 feet, is equipped with 45 trays. It operates at 115 pounds pressure and its reboiler operates at 151° F. Under these conditions the overhead product is 98 percent iso-butane. After condensation it is pumped back over the column at 11:1 reflux ratio. The excess goes to storage for disposition as material for the manufacture of aviation gasoline. The n-butane goes to pressure storage to be used as such or blended with propane for making liquefied petroleum gas.

A resume of the operating conditions show the following:

Depropanizing Column

Column pressure, pounds	240
Reboiler temperature, °F	273
Top temperature, °F	105 to 110
Reflux ratio	2.5:1

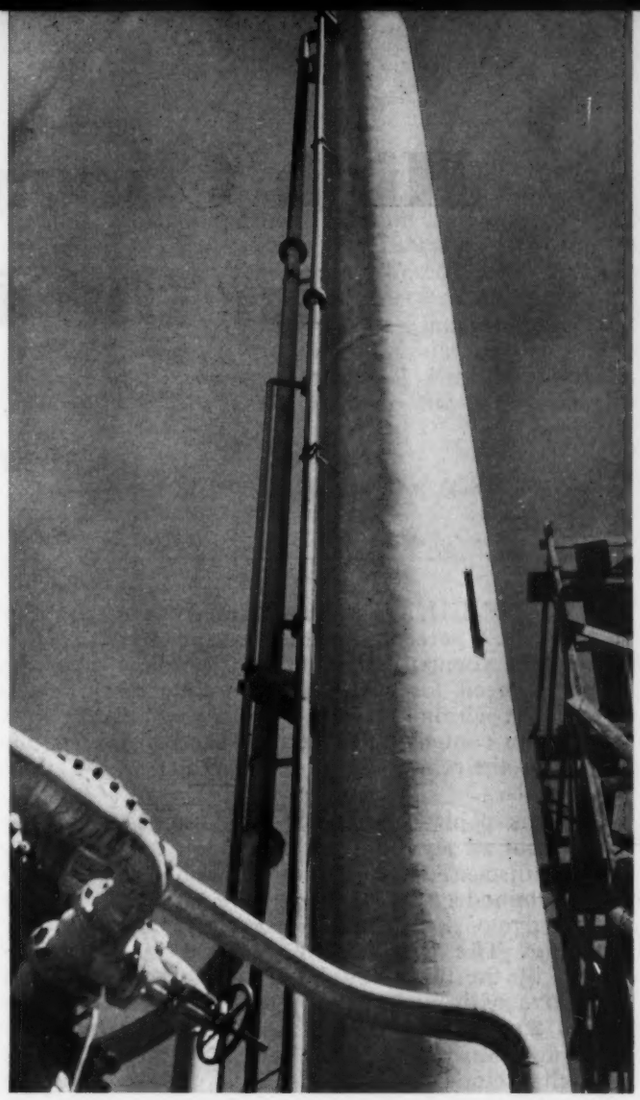
Debutanizing Column

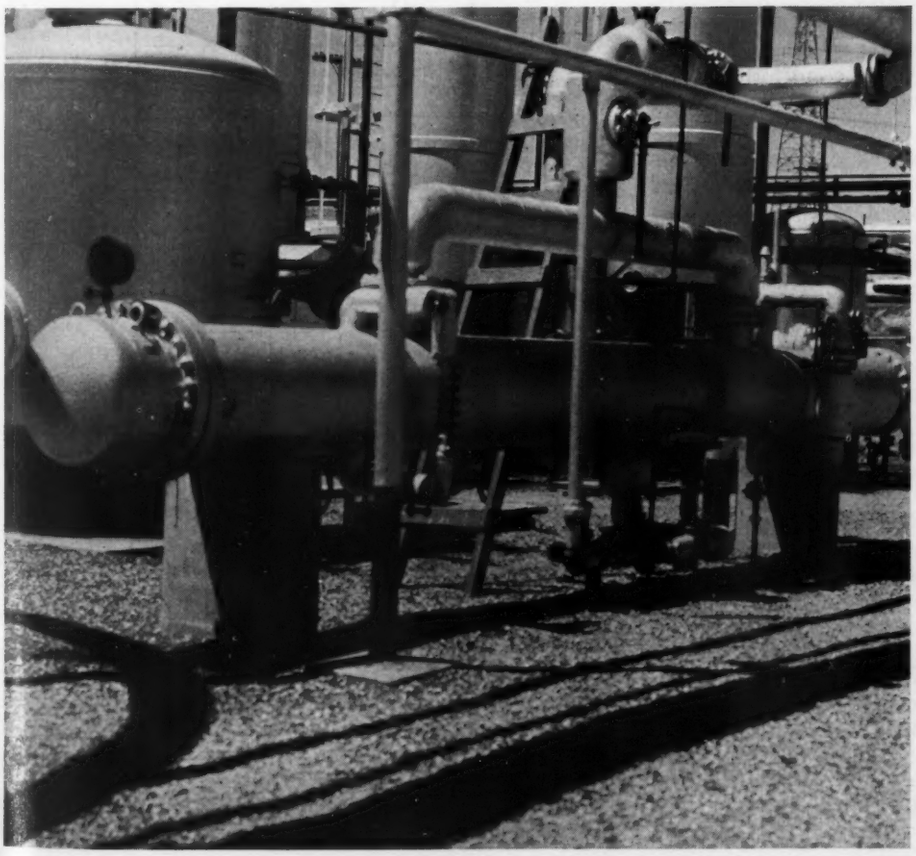
Column pressure, pounds	94
Reboiler temperature, °F	217
Reflux ratio	3.5:1

Iso-Butane Column

Column pressure, pounds	115
Reboiler temperature, °F	151
Reflux ratio	11:1

Overhead product as I-butane 98 percent pure.
Bottom product as N-butane 98 percent pure.





Iso-butane column, showing height of feed connection, reflux and iso-butane vapor line.

Lean oil chilling unit

High Chromium Alloys In the Refinery

WELDON L. ARCHER

ALTHOUGH, as has been pointed out in an earlier article, the 5 percent chromium steels have been performing a yoeman's service for the refiner, at times there is need for a higher chromium alloy. From 5 percent chromium a large step is taken to a chromium content of 12 percent. And in taking this big jump the refiner enters the dominion of the stainless steels.

At this point it is well to explain that there is nothing at all mystifying about stainless steels. They will be discussed step by step in simple language in a determined effort to bridge the gap between the knowledge of the metallurgist and that of the refinery operator. The first logical question is: "What is meant by the term 'stainless'?" Stainless, as applied to alloys of iron, has come to mean the ability to resist atmospheric corrosion at ordinary temperatures forever. Chromium, above 11 percent, imparts this characteristic to steel. Thus by common usage all steels containing in excess of 11 percent chromium, with or without nickel, are known as stainless steels. Remember such steels are stainless in the atmosphere at room temperatures. They are not cure-alls. Neither are they corrosion proof under all conditions. As a matter of fact many chemicals readily attack the stainless steels.

Bearing in mind the limitations of the materials under consideration, attention may now be directed to the special attributes of the stainless steels that make them useful to the refiner. Briefly, these high-chromium alloys offer excellent resistance to oxidation at high temperatures; they afford pronounced resistance to corrosion in many service applications; they possess fine physical properties at elevated temperatures (in general, only, as the embrittlement of the 27 percent chromium alloy in the temperature range 800-1000° F. must be acknowledged); and their creep strength is outstanding. These special functions will be considered at length as soon as we locate the 6 high-chromium alloys most commonly used on the map. Fortunately the 6 materials fall into 3 distinct and understandable fields: the martensitic alloys, the ferritic alloys and the austenitic alloys. Now, the terms martensite, ferrite and austenite will all be explained immediately as the three classifications are made clear.

In order to fully understand the three new metallurgical terms introduced (new to the non-metallurgist) consider for a moment the heat treatment of steel. The blacksmith heats a piece of carbon steel red hot and plunges it into water. The steel, provided that there was enough carbon present, becomes hard. What happened?

Steel exists in two forms: the so-called low-temperature form, or ferrite, and the so-called high-temperature form, or austenite. Ferrite is alpha iron which is magnetic and characterized by its inability to hold much carbon in solution. At room temperature the solubility of carbon in alpha iron, ferrite, is less than 0.01 percent. That is not very much when you consider that the ordinary low-carbon steel plate used in refinery vessels contains from 10 to 20 times this amount of carbon. When the blacksmith heated his piece of steel red hot, he formed another type of constituent, austenite. Austenite, or gamma-iron, is non-magnetic. Furthermore austenite has the ability to hold a large amount of carbon in solution. At room temperature austenite will hold as much as 1.7 percent carbon in solution. Therefore the blacksmith heated the steel to change the crystalline form

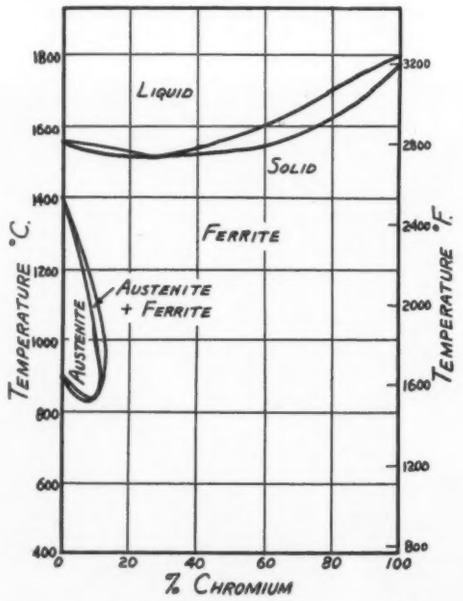


FIGURE 1
Simplified iron-chromium system

of iron from the alpha type that cannot hold much carbon in solution to the gamma type that can.

Had the blacksmith cooled the piece very slowly the austenite would have changed back to ferrite and the extra carbon would have formed an iron carbon compound, Fe_3C, which is known as cementite. That is the original state in which the piece of steel existed before it was heated. That is ferritic steel. Ferritic steel is soft and ductile, far from the hardened mate-

TABLE 1

Stainless Steels by Classes

Martensitic	Ferritic	Austenitic
12% Chromium	17% Chromium 27% Chromium	18% Chromium— 8% Nickel 25% Chromium—12% Nickel 25% Chromium—20% Nickel

rial the blacksmith sought. But by quenching the steel in water there was not enough time for ferrite and cementite to form. Instead the carbon was held rigidly in a new structure, martensite. Martensite is very strong. But martensite is not ductile. Instead, it is hard and brittle. The big bugaboo in the fabricating of martensitic stainless steels with heat is this tendency to form martensite with the attendant danger of cracks.

To assist in the problem of understanding the behavior of stainless steels in different services, Figure 1 presents a simplified diagram of the iron-chromium system. This diagram represents a practically carbon-free system. As this discussion is confined to the very low-carbon stainless steels that represent the greatest tonnage in refinery work, the diagram will suffice.

Table 1 lists the most common stainless steels. The martensitic steels are hardenable and magnetic, the ferritic steels are non-hardenable and magnetic, and the austenitic steels are non-hardenable (by heat treatment) and are non-magnetic.

In order to be hardenable a steel must go through the ferrite to austenite transformation. Twelve percent chromium stainless, a martensitic alloy, enters that portion of the austenitic field shown in Figure 1 and thus is hardenable. Although the austenitic loop appears small in the drawing the influence of the normal amount of carbon moves the loop to the right and definitely includes the 12 percent chromium analysis. But not so far to the right as to include either the 17 percent chromium analysis or the 27 percent chromium analysis. As these materials are always ferritic, they cannot be hardened.

Time is an important element in all heat treatment. The blacksmith quenched his piece of steel in water to cool it quickly. For only by cooling carbon steel quickly may full hardness be developed. But alloys such as chromium and chromium and nickel in combination change the time element. They slow down the rate of transformation from austenite to ferrite, leaving much more time in which the hard martensite can form. If an ordinary piece of steel is cooled in air, it will contain ferrite without any martensite as a general rule. Only by rapid cooling is the hard constituent formed. Not so with 12 percent chromium steel. Here the rate of transformation has been slowed down by the chromium until hard martensite results from simple air cooling.

Carbon is the element that controls the degree of hardness. By restricting the amount of carbon in the 12 percent chromium analysis air-hardening tendencies can be kept to a practical minimum. Sometimes titanium, columbium or aluminum are added to the 12 percent chromium stainless to serve as an antidote to the hardening tendencies, thereby keeping the material soft after welding or other heating.

Of course the stainless steels are made by melting and hot rolling. In the course of manufacture they are cooled to room temperature. From the liquid state in which they are made to the solid state in which they are rolled they go from liquid metal to solid austenite. Cooling from austenite to ferrite is the next step with ordinary steels. But the highly alloyed stainless steels of the austenitic class never form ferrite. The rate of transformation from austenite to ferrite is very slow, requiring in some cases hundreds of years to be completed. For this reason the austenitic stainless steels are both non-hardenable and non-magnetic. They retain the high temperature form of iron at all times. Sometimes they lose ductility and become hardened as a result of cold working. Never by heat treating are these steels hardened. And surprisingly enough, they are softened, or annealed, by heating to about 1950° F. and quenching in water. This is the same treatment that would harden most carbon steels.

TABLE 2

Common Analyses of the Stainless Steels

STAINLESS	Type	Carbon	Manganese	Silicon	Chromium	Nickel
12% Cr.	410	0.10	0.50	0.30	12	..
17% Cr.	430	0.10	0.50	0.30	17	..
27% Cr.	466	0.15	0.70	0.30	27	..
18% Cr.— 8% Ni.	302	0.10	0.50	0.50	18	8
25% Cr.—12% Ni.	309	0.15	1.00	0.70	25	12
25% Cr.—20% Ni.	310	0.15	1.00	0.70	25	20

TABLE 3

Comparative Scaling Temperatures of Stainless Steels

STAINLESS STEEL	Scaling Temperature in °F.
12% Cr.	1300
17% Cr.	1550
27% Cr.	2100
18% Cr.— 8% Ni.	1650
25% Cr.—12% Ni.	2100
25% Cr.—20% Ni.	2150

Before going into the special properties, applications and welding of the stainless steels, Table 2 lists the common analyses and type numbers of these materials. As the total amount of the alloying ingredients increases, the permissible carbon content shows a rise. In general the corrosion resistance of the stainless alloys increases with the amount of chromium present and decreases with the amount of carbon. From this relationship the explanation for the higher allowable carbons becomes obvious. In the very highly alloyed types containing at least 25 percent chromium, as do types 446, 309 and 310, the somewhat greater percentage of carbon does not affect the resistance to corrosion adversely.

With operating temperatures showing a continued rise the refiner becomes more and more interested in the scaling temperatures of the materials he uses. Table 3 reports the scaling temperatures of the stainless steels under consideration. Roughly the temperatures are proportional to the amount of chromium in the steels with nickel playing the minor role in this application. Not only is scaling in air important but also is scaling in an atmosphere charged with hydrogen sulfide of much interest to the operator. Table 4 shows the results of scaling tests conducted under varying conditions.

The scaling temperatures reported in Table 3 are those that lead to spalling of the oxide formed. Of course all the stainless steels exhibit temper colors, showing the presence of a tightly adhering oxide or scale at lower temperatures. As a rule the ferritic stainless steels lose less scale at elevated temperatures than do the austenitic alloys. This is due in a

TABLE 4

Scaling Tests of Stainless Steels

TEST CONDITIONS	TYPES				
	12 Cr.	17 Cr.	27 Cr.	18-8	25-12
50 hr. 1650° F. in Air	0.7	0.7	....	....	....
50 hr. 2010° F. in Air	250.0	7.0	2.5	15.0	9.0
50 hr. 1800° F. in Hydrogen Sulfide	1000.0	930.0	820.0	....	....

(Gain in weight expressed in mg. per sq. cm.)

large measure to the lower coefficients of expansion possessed by the ferritic alloys. There is less movement of the ferritic types on repeated heating and cooling and so less flaking of scale.

An interesting picture of the influence of temperature on the scaling of chromium bearing steels is presented in Figure 2. The lower curve is equivalent to an amount of scaling equal to 1mg. per sq. cm. while the upper curve corresponds to an amount equal to 10 mg. per sq. cm. Here, again, is shown the pronounced influence of the chromium on scaling resistance with this behavior being almost directly proportional to the amount of chromium present.

The chromium steels possess lowered resistance to oxidation under conditions that are reducing. The presence of either carbon-monoxide gas or carbon leads to the formation of chromium carbide, thereby depleting the surface of an appreciable amount of chromium. With a lessened amount of chromium the scaling increases.

One of the important considerations in high-temperature applications of ferrous materials is their strength at elevated temperatures. Here the chromium alloys are fairly good while the austenitic types, as is demonstrated in Table 5, are much better.

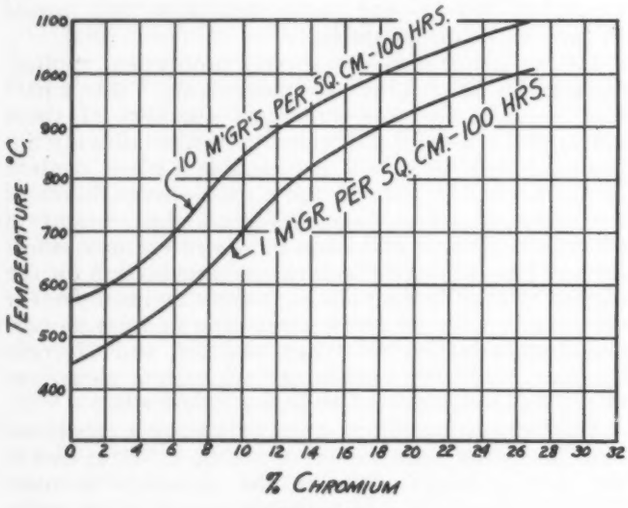


FIGURE 2

Scaling of chromium-iron alloys

Note that the nickel-bearing stainless alloys possess decidedly more strength at the highest temperatures. The 17-percent-chromium steel has a decline in elongation from 200° F. to 800° F. Even worse is this trend in the 27-percent-chomium alloy where the ductility from 600° F. to 1000° F. is reduced. In the 17-percent-chromium analysis all of the elongations stay above 20 percent in 2 inches which is ample for almost all services. On the other hand the higher-chromium material falls below this value in several places.

When operated above 700° F., the stainless steels are called upon to perform still another task. They must resist flow. They must possess adequate creep strength. This creep strength has been determined for the most of the stainless materials by means of investigation of the stress-strain-time relationships.

Whereas most of the carbon steels may be used in services not exceeding 1000° F. under light stress conditions, it is more common to see low-alloy steels such as carbon molybdenum applied to the temperature range of 800° F. to 1100° F. As the temperature of operation rises above 1100° F., the stainless steels come into their own with excellent creep strength accompanied by superior resistance to both oxidation and corrosion.

The phenomenon responsible for relaxation of bolts

TABLE 5

Short Time Tensile Tests on Wrought Stainless Steels

(1 hr. at temperature—pulled 0.05 in. per min.)

Material	Temperature, ° F.	Ultimate Strength, psi	Elongation % in 2"	Reduction of Area, %
12 Cr. (Type 410)	Room	89,370	32.0	71.4
C 0.12, Mn 0.42,	200	83,170	29.0	75.0
P 0.014, S 0.020,	400	76,580	28.0	76.0
Si 0.18, Cr 12.27,	600	72,850	25.0	73.6
Ni 0.204 (annealed)	800	66,140	25.0	70.3
	900	54,700	26.0	73.2
Brinell hardness 187	1000	44,750	26.0	77.5
	1100	34,700	43.0	87.3
	1200	24,810	50.0	92.9
	1300	15,160	58.0	95.3
	1400	9,200	68.0	97.9
	1500	9,450	78.5	73.4
	1600	9,740	69.0	41.9
17 Cr (Type 430)	Room	76,580	32.0	74.4
C 0.07, Mn 0.30,	200	71,860	30.0	74.0
P 0.013, S 0.020,	400	67,140	27.5	75.8
Si 0.29, Cr 16.56,	600	63,900	26.0	75.2
Ni 0.157	800	56,190	29.0	74.6
	900	48,980	34.0	75.6
Brinell hardness 179	1000	35,800	35.5	84.4
	1100	26,850	55.0	90.8
	1200	18,650	61.5	97.1
	1300	11,440	67.0	99.1
	1400	7,460	70.0	99.5
	1500	5,090	83.0	99.8
	1600	3,480	188.00	98.4
27 Cr (Type 446)	Room	93,480	26.0	59.6
C 0.10, Mn 0.74,	600	83,170	19.5	53.5
P 0.021, S 0.014,	800	82,380	19.0	47.5
Si 0.13, Cr. 30,	900	80,630	20.5	41.6
Ni 0.57	1000	70,520	15.0	47.2
	1100	39,280	47.0	73.2
Brinell hardness, 163	1200	24,210	47.0	85.2
	1300	10,860	57.0	90.7
	1400	6,890	80.0	93.0
	1500	4,245	133.0	97.7
	1600	3,355	165.0	98.8
18-8 (Type 304)	Room	91,500	68.0	75.5
18% Cr, 9% Ni,	200	78,600	59.0	79.5
0.07% C Max.	400	70,250	47.0	73.1
	600	71,430	46.5	70.6
	800	67,025	45.2	68.8
	900	64,480	40.2	69.1
	1000	61,625	44.5	69.0
	1100	53,740	40.7	64.8
	1200	44,375	46.7	64.1
	1300	35,620	50.7	58.2
	1400	23,650	53.2	51.0
	1500	17,210	54.5	47.2
	1600	14,500	50.0	45.0
25-12 (Type 309)	Room	79,880	71.0	81.0
C 0.082, Mn 0.97,	200	72,520	56.0	80.0
P 0.014, S 0.013,	400	66,890	52.5	78.0
Si 0.38, Cr 22.94,	600	66,530	47.5	75.0
Ni 12.72	800	66,400	48.0	72.0
	900	61,680	47.0	72.0
	1000	60,920	48.0	69.0
	1100	54,920	41.5	50.0
	1200	44,680	28.0	31.0
	1300	36,570	27.5	28.0
	1400	28,610	25.0	31.0
	1500	21,470	38.0	33.0
	1600	15,970	29.5	32.0
25-20 (Type 310)	Room	82,380	55.0	79.0
C 0.07, Mn 1.22,	300	73,350	51.5	78.0
P 0.023, S 0.021,	500	69,870	45.0	75.0
Si 0.35, Cr 24.99,	700	70,620	48.0	73.0
Ni 20.46	900	69,120	50.5	71.0
	1000	66,760	50.0	67.0
	1100	60,170	41.0	45.0
	1200	47,500	24.0	29.0
	1300	41,190	24.0	26.0
	1400	31,950	26.5	27.0
	1500	24,360	37.0	37.0
	1600	17,900	33.0	46.5

.505 in dia x 2 in. gage length specimens.

TABLE 6
Creep Strength of the Stainless Steels

Temp. °F.	0.11% C 12 Cr	0.10% C 17 Cr	0.20% C 27 Cr	0.06% C 18-8	25-12	0.12% C 25-20
Stress Causing Creep Rate of 1% Elongation in 10,000 hours						
900	.....	.....	.....	24,000	.....	.....
1000	13,000	8,500	.....	17,000	.....	.....
1100	5,200	5,200	.....	11,550	.....	.....
1200	2,100	2,100	1,600	7,000	.....	7,400
1350	1,400	1,200	400	3,000	.....	3,300
1500	.....	.....	.....	850	.....	1,100
Stress Causing Creep Rate of 1% Elongation in 100,000 Hours.						
800	.....	.....	.....	25,300	.....	.....
900	.....	.....	.....	18,000	.....	.....
1000	10,000	7,000	.....	11,500	.....	.....
1100	4,000	4,500	.....	7,100	.....	.....
1200	1,600	1,600	1,000	4,250	.....	5,400
1350	900	900	180	1,600	.....	2,800
1500	.....	.....	.....	.....	.....	800

in high temperature applications is creep. The material elongates very slowly under load and this movement, or flow, has come to be known as creep. Since creep is a long-time property of a material, creep data is reported in terms of the stress that will produce an elongation of 1 percent in 10,000 hours or 1 percent in 100,000 hours. Of course the stress required to produce an elongation of 1 percent in 10,000 hours is greater than that required to produce the same elongation in 100,000 hours. But, as shown in Table 6, the stress required to bring about 1 percent elongation in the shorter time is not near 10 times that required for a specified elongation in the longer period of time.

As most of the steels used by the refineries come into the straight chromium stainless class in the martensitic type, there may be some question as to the reason for delineating all of the other alloys. Although both the ferritic and the austenitic types are used to a lesser extent, they are important wherever service conditions indicate their need. Furthermore as operating temperatures and pressures become increasingly severe, the need for more highly alloyed materials will become apparent. Then the increased resistance to both oxidation and creep possessed by the austenitic alloys will be found most valuable.

Before leaving the physical properties of the stainless steels mention must be made of some of the modifying elements added to the steels for specific purposes. The straight chromium steels have additions of silicon, molybdenum, titanium, columbium or aluminum added to make an improvement in some physical properties for special applications. Most of these elements reduce the air-hardening tendencies of the straight chromium materials with aluminum having been used widely for this reason.

Perhaps even more modifications have been made in the analyses of the austenitic stainless steels. As many of these changes, particularly the additions of titanium and columbium, are made in the interests of improved corrosion resistance as well as greater ease of fabrication.

Corrosion in the refinery takes place in both the hot and the cold phases of operation. In the hot phase most of the damage results from the ravages of sulfur and sulfur compounds of which there is an almost endless variety. The cold phase brings about corrosion from some sulfur compounds although the acids are predominantly troublesome here. Among the more common acids encountered are hydrochloric, phosphoric, sulfuric and sulfurous. In addition organic acids may be present.

In any discussion of corrosion it is well to mention the strange behavior of this activity. Of all the enemies of man corrosion is one of the worst. Much money has been spent on the study of corrosion with almost all of the data applying to some specific set of conditions. Corrosion problems vary from refinery to refinery, from vessel to vessel and, not at all unusual, from month to month. These idiosyncracies should not serve to frighten the engineer faced with the selection of a corrosion-resisting alloy. Rather they should serve to notify him of the need for definite information about the actual installations as a guide to the proper selection of material. Wherever possible, corrosion tests should be conducted with the aid of the supplier of the alloy. It is indeed fortunate that so many installations of the stainless steels have resulted from the close co-operation of refinery engineers and steel-mill metallurgists whose combined knowledge has led to the choice of the proper material. In a few cases the 5-percent-chromium alloys have sufficed. In most instances the 12-percent-chromium material has proved to be ideal. And in other cases the adoption of an austenitic material, usually 18-8, was justified.

Stainless steels have been applied to many parts of the modern refinery. Among the varied uses for these alloys are bubble caps, bubble trays, shell linings, pumps, valves, and vapor lines. Included in the minor applications are gaskets, floats and thermocouple protection tubes.

Both bubble caps and bubble trays present almost identical reasons that promote their acceptance notwithstanding a higher first cost than either cast iron or mild steel. The many operating advantages serve to make the long-term cost less than that of the unalloyed materials formerly tried. Of course the substitution of a tough, ductile material for cast iron eliminates troublesome breakage. Caps need not be replaced because of missing teeth while damaged trays do not occasion costly delays.

Possibly one of the more outstanding features of the chromium alloys is their freedom from coking. The old familiar chipping away of accumulated coke during down time is banished. In addition this absence of coking allows longer runs and more efficient operation throughout the run as trays and caps remain clear. The ease with which these materials may be fabricated leads to a wider variation of design, promoting further operating economies. At the same time the lighter weights of removable trays and caps leads to savings in insurance rates as the number of accidents to workmen are reduced.

The subject of liners has been discussed thoroughly before, eliminating the need for a lengthy discussion here. Either lined vessels are specified for corrosive service in new designs or liners are installed in existing vessels. Many pressure vessels are operating solely because of the existence of the high-chromium alloys. At the first sign of extensive damage through the ravages of corrosion, the alert operators of these units installed stainless liners. By this means the thickness of the vessel wall was saved from dangerous reduction, permitting continued operation of the equipment with no diminution of the factor of safety after the original corrosion allowance was gone. In new vessels of considerable wall thickness the alloy liner may be paid for almost wholly out of the savings in weight brought about by the elimination of

TABLE 7
Effect of Silicon on Oxidation Resistance of 18-8

	Held 36 Hr. at 980° C. (1800 °F.)			Held 72 Hr. at 980° C. (1800° F.)	
Silicon, Percent	Penetration, In. Per Year	Loss, Mg. Per Sq. Dm. In. Per Day	Silicon, Percent	Penetration, In. Per Year	Loss, Mg. Per Sq. Dm. Per Day
0.40.....	0.88	4769	0.52.....	1.51	8184
1.10.....	0.49	2656	1.86.....	0.39	2114
2.14.....	0.043	233	3.62.....	0.009	48.8

the sacrificial thickness formerly allocated to "corrosion allowance." Very often high-temperature services combine the choice of carbon-molybdenum steel for excellent creep resistance with that of alloy liners for permanent escape from corrosion troubles, to bring about an overall saving in initial purchase price.

As far as vapor lines are concerned, they may be made of solid alloy piping. Sometimes, where the diameter is large, less expense is involved by ordering carbon steel or low-alloy piping with a high-chromium-alloy liner.

Manufacturers of both pumps and valves are following the trend to the stainless alloys. These important pieces of equipment may be likened to the human heart and circulating system and their trouble-free operation is almost as important. Both the straight chromium and the chromium-nickel

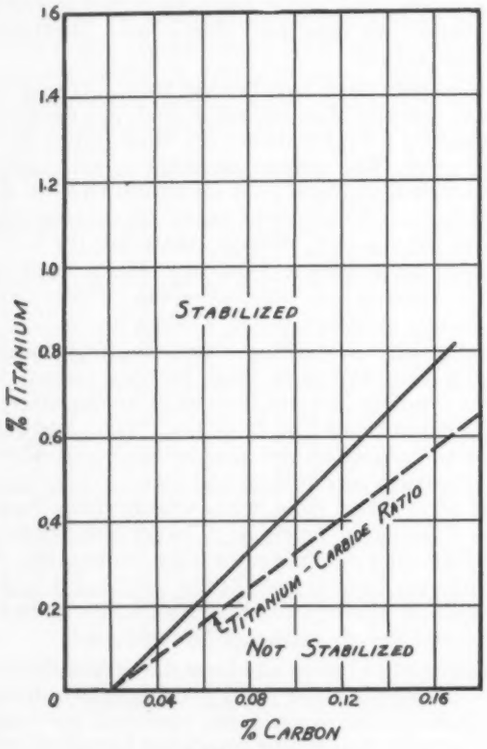


FIGURE 3
Stabilization by titanium addition

alloys are suited to these refinery operating points with the latter getting the edge because of their expediency in fighting corrosion in either hot or cold applications.

Prior to considering the fabrication of the high chromium materials some attention should be given to the modifications of analysis to be found in the chromium-nickel alloys. The simple types discussed so far are the basic types. No mention of the many slight changes that account for the wide variety of stainless types has been made in the early portion of this article.

Because of the high coefficient of expansion of the 18-8 steels, almost 50 percent greater than that of ordinary steels, repeated heating and cooling causes the scale to flake. This action permits progressive oxidation. But the addition of 2 to 3 percent of silicon improves the resistance to oxidation, making the chromium-nickel-silicon steels a wise choice in high-temperature service where resistance to oxidation is of paramount importance. Silicon tends to reduce the impact strength on repeated heating in the range from 1110° F. to 1650° F. Increasing the nickel from 8 to 10 percent helps correct this condition. Table 7 points out the relationship between the amount of silicon added to 18-8 and its resistance to oxidation.

Of increasing interest of late has been the addition of from 2 to 4 percent of molybdenum to 18-8 to reduce hit corrosion. At the same time an increase in the high-temperature strength results. A material improvement in creep strength results from this same addition.

Not all the special elements added to the austenitic stainless steels, particularly 18-8, are reviewed because some of these applications hold no interest for the refiner. Less than ten years ago, however, the use of titanium and columbium was advocated to prevent the rapid attack of 18-8 stainless steels as a result of intergranular corrosion.

In the range of temperatures from 800° F. to 1500° F. chromium carbide precipitates in a short time in the grain boundaries. This carbide is formed at the expense of the chromium in the grains adjacent to the boundaries. Through this mechanism the effective chromium content alongside the grain boundaries is reduced sufficiently to allow corrosion to start at that point. As most welding operations involve heating a portion of the material in the sensitive range, the advent of titanium and columbium to stabilize 18-8 steel against the formation of chromium carbides leading to intergranular attack was a welcome addition to the metallurgical art.

Titanium in an amount about 6 times the carbon content and columbium in an amount about 10 times the carbon content of the steel brings about stabilization. The mechanism of this immunization is simple. Both titanium and columbium are strong carbide formers. That is, they will combine with the carbon present before the chromium has a chance to do so. Thus titanium and columbium carbides are formed leaving ample chromium in the grains to resist corrosive attack.

In Figure 3 is illustrated both the amount of titanium necessary to form the required titanium carbide as well as the amount needed to immunize the steel from intergranular attack. Not only is the titanium beneficial in preventing intergranular deterioration but also does this element aid the impact strength at elevated temperatures after long exposure as is shown in Figure 4. Nor, as is shown in Table 8, are the mechanical properties of the titanium bearing 18-8 unduly affected by the addition of titanium. Because of the difficulty involved in the proper heat treatment of the 18-8 alloys to prevent sensitization, the titanium alloy comes well recommended. In some cases ordinary 18-8 has been heated to 1800° F. to 1900° F. and rapidly quenched in water to prevent the intergranular attack. Still, when

TABLE 8

Effect of Titanium on the Mechanical Properties of Wrought 18-8 Steels, After Air Cooling From 1050° C. (1920° F.)

Composition, Percent				Tensile Stgth, Psi	Yield Stgth, Psi	Elongation, % in 2"	Reduction of Area, %	Izod Impact, Ft.-Lb.
C	Cr	Ni	Ti					
0.10....	18.77	8.46	....	93,800	39,000	67	74	120
0.08....	18.58	9.68	0.42	86,500	38,100	59	64	111

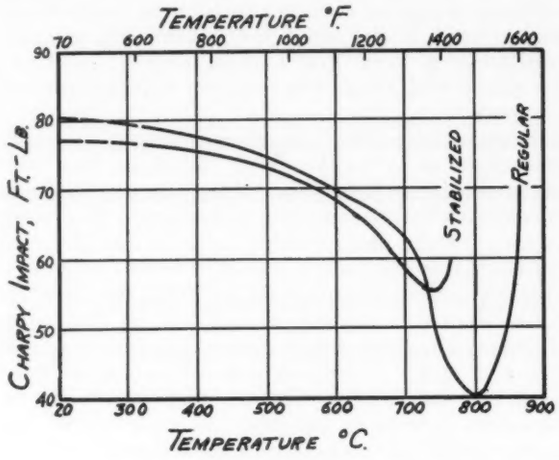


FIGURE 4

Impact strength of Ti-stabilized and regular 18-8 after 1000 hours at indicated temperatures.

the many dangers that attend the quenching of a large structure in water are considered, the specification of a stabilized alloy presents the safest approach to the problem.

Columbium performs in about the same manner as titanium. Because of a decrease in ductility of wrought columbium-bearing chromium-nickel steels if too much columbium (over 1 percent) is added, the usual specification covers the range of 0.70 to 1.00 percent. One fact must not be lost sight of in considering loss of ductility as applied to stainless steels adapted for refinery service. The ductility of all the 18-8 steels is quite good. In fact their ductility is much better than that of the ordinary carbon steels. Therefore, in refinery applications, a loss of ductility that might prove fatal in a deep drawing problem, is of little consequence to the refiner. Figure 5 compares the effect of columbium on the impact resistance of stabilized 18-8 with a straight 18-8 based upon the data presented in Table 9. The general improvement of impact values through the range of temperatures, investigated is apparent. Any reduction in ductility is well worth the increase in impact strength.

The refiner is interested in the fusion welding of the stainless steels for two reasons. First, he must know something of the welding problems associated with the manufacture of new equipment designed and purchased by him. Second, he must be concerned with the correct welding procedure required in the repair, maintenance and modernization of existing equipment. For these reasons the discussion of the welding of the stainless steels will be restricted to practical considerations for the sake of brevity while, at the same time, every effort will be made to make this review comprehensive.

Once more a subdivision must be made to differentiate between the welding of the straight chromium steels, both ferritic and martensitic, and the chromium-nickel, or austenitic, varieties. Whereas the plain chromium steels may be welded with filler metal of either like or unlike chemical compositions, the chromium-nickel types are almost always welded using similar analyses. Adding still further to the choice of filler metals is the problem of joining the carbon steels to the highly alloyed materials.

Before going into a detailed discussion of the selection of welding electrodes it is well to consider the existing fusion welding processes in order to discover the most suitable method of joining the stainless steels. Four welding methods are commonly found in this work. These are the oxy-acetylene, metallic arc, carbon arc and atomic hydrogen. Two of these processes find the most wide-spread application: the oxy-actylene and the metallic arc. In general the gas process is restricted to thicknesses of 1/16-inch. On the other hand the metallic arc process may be used by the refiner for everything from the lightest gauges to heavy plate thicknesses. Because of the flexibility of the metallic arc method, no attention will be paid in this discussion to the other welding schemes, notwithstanding the excellence of their performance in other fields.

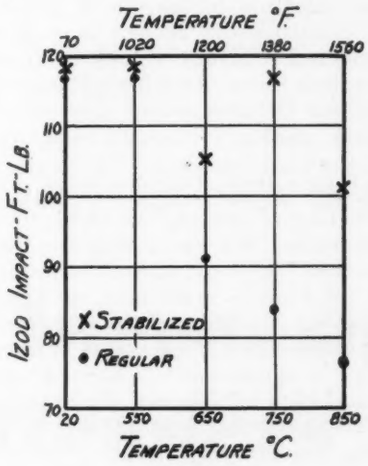


FIGURE 5

Impact strength of Cb-sterilized and regular 18-8 after two weeks at indicated temperatures.

TABLE 9

Effect of Columbium on Resistance to Long Exposure to Elevated Temperatures of Chromium-Nickel Steels Previously Water Quenched From 1150° C. (2100° F.)

Composition, Percent						Held 2 Weeks* At		Izod Impact Value, Ft.-Lb.
C	Mn	Si	Cr	Ni	Cb	°C.	°F.	
0.06	0.51	0.28	18.85	9.21	....	....	....	118
....	....	....	....	....	....	550	1020	118
....	....	....	....	....	....	650	1200	91
....	....	....	....	....	....	750	1380	84
....	....	....	....	....	....	850	1560	77
0.08	0.54	0.42	18.04	8.86	0.78	....	....	119
....	....	....	....	....	....	550	1020	119
....	....	....	....	....	....	650	1200	105
....	....	....	....	....	....	750	1380	117
....	....	....	....	....	....	850	1560	101

* Then air cooled.

No doubt some of the peculiarities involved in welding the stainless steels may be attributed to differences in physical properties. Thermal conductivity is materially reduced while electrical resistance is greatly increased. The thermal conductivity ranges from 1/3 to 1/2 that of mild steel while the electrical conductivity averages approximately 1/6 that of the unalloyed material. This combination

brings about the lower currents needed in the metallic arc welding of the stainless steels.

Another physical property that has been much mentioned is that of thermal expansion. The straight chromium steels have a thermal expansion about 10 percent less than that of mild steel. This difference is not great enough to warrant all the attention it has been given. But the austenitic stainless steels, possessing as they do a 50 percent greater coefficient of thermal expansion, deserve particular attention in design and fabricating considerations. Another factor leading to the use of lower welding current is the lower melting point of the high chromium alloys.

Another general point is that of electrode sizes. Although the most popular diameters encountered in the welding of mild steel are 5/32-, 3/16- and ¼-inch, the comparable popular diameters in stainless steel work are ⅛- and 5/32-inch. Infrequent indeed is the choice of an electrode as large as 3/16-inch in diameter. Not only the diameters but also the lengths are reduced. Mild-steel welding calls for electrodes either 14 or 18 inches long; stainless steel welding, because of the greater electrical resistance of the electrodes, leads to the selection of lengths 9, 11 or 14 inches. Sometimes electrodes 18 inches long with a center grip are selected. Current values of from 10 to 15 percent less than those fitted for mild-steel electrodes are required for the austenitic alloy filler metal.

Very often specially trained welders must be assigned to the stainless steel jobs. As the weld metal is sluggish, the ordinary welder, accustomed as he is to the welding of low-carbon steel, tends to overheat his electrodes. Wherever welders can be trained to choose correct current values without becoming alarmed at the viscous weld pool, no need exists for unusual training. In spite of the apparent sluggishness of the deposit, finished welds are uniform and are attractive in appearance. Lower currents, smaller electrodes and high initial cost of electrodes all point to the need for careful supervision of all stainless-steel welding. Fortunately spatter loss is remarkably low, leading to excellent deposit efficiency.

Practically all this welding is done with direct current and reverse polarity. Maintaining a short arc to avoid the loss of important alloying ingredients, the welder manipulates his electrode in much the same manner as he does in ordinary welding. Care must be observed to avoid puddling the metal or weaving in a figure eight pattern, as overheating the weld metal is certain to result. A detrimental aftermath of overheating are the cracks coming, upon cooling, from the hot-short weld deposit. Stainless steel deposits are not commonly hot-short; this condition is only brought about by overheating. There is another source of cracking that should be pointed out. The use of thick layers which afford considerable restraint during cooling may lead to cracks. A surefire remedy is found in many layers sufficiently thin to yield while cooling.

Mention was made in passing of the need for a short arc to minimize the loss of alloying elements. As most modern electrode manufacturers depend on the use of highly alloyed core wires with a minimum of ferro alloys in the coating, some loss is to be anticipated. Most often the core wire is of the proper composition with enough ferro elements in the coating to replace those lost in the arc. About 1 to 1½ percent chromium is lost in the arc while nickel passes unchanged into the deposit. Infrequently mild steel cores are combined with a coating that contains all of the alloying ingredients. This combination results in a chromium loss of almost 4 percent.

Speaking of losses brings to mind a reason for preferring columbium to titanium in core-wire analyses. The recovery of columbium in the deposit is comfortably high whereas almost all of the titanium becomes lost in the journey through the arc. But the use of columbium-bearing stabilized electrodes are not as great as that of the plain 18-8 type. Only where cross welds or welds in sections ½-inch or more thick are encountered is the need for columbium extant. By employing a very low carbon deposit with ample chromium and nickel the need for columbium may be obviated.

Because like filler metal introduces more problems than does unlike filler metal in the welding of the straight-chromium types, there may be some question as to the reason for desiring a like analysis. As long as the ideal welded joint is one that closely approximates the parent metal in both chemical composition and mechanical properties, the desirability of like deposits becomes a function of the operative environment. Sometimes stress considerations influence the choice. Temperatures of operation may become the determining factor. The possibility of accelerated corrosion because of electrolytic factors may prohibit the inclusion of unlike weld metal. Perhaps the impossibility of annealing after welding may rule out the embodiment of like weld metal. This somewhat confusing state of affairs warrants close cooperation between user and supplier before the exact welding procedure may be decided upon.

Because of the many pitfalls awaiting the uninitiate along the path of straight-chromium-steel welding, many recommendations have been based upon the use of an austenitic deposit for joining all straight-chromium alloys. In the vast majority of refinery applications this procedure has proved worthwhile. Certainly all repair work which by its very nature may not be annealed in situ must be done with an unlike deposit.

Two distinct reasons exist for the need of heat treating the straight-chromium stainless steels. Twelve percent chromium, or martensitic stainless, develops a very hard heat-affected zone upon welding. Usually this tendency is minimized by the inclusion of titanium, columbium or aluminum. But where the plain analyses are welded heat treatment by furnace annealing to a temperature range of 1400° F. to 1500° F. should be followed by slow cooling. Because of the sluggish transformation of these high alloys, it is necessary to hold at the elevated temperature for a long period: not less than one hour per inch of thickness and, at times, as long as four hours per inch of thickness.

High-chromium, ferritic, stainless steels may be welded satisfactorily with like weld metal. Sound and tight welds are readily made as regards both porosity and fusion. Here a brittle heat-affected zone is found not as a result of martensitic hardening but rather as an aftermath of the coarse crystalline structure formed at the welding temperatures. This extremely coarse-grained structure possesses little ductility. Nor may this ductility be completely restored by either heat treatment or annealing. In view of this condition, welded equipment of the ferritic stainless steels is not warranted in applications where they are subject either to shock or to bending stresses.

The ductility of these alloys increases rapidly upon

[*Continued on page 85*]

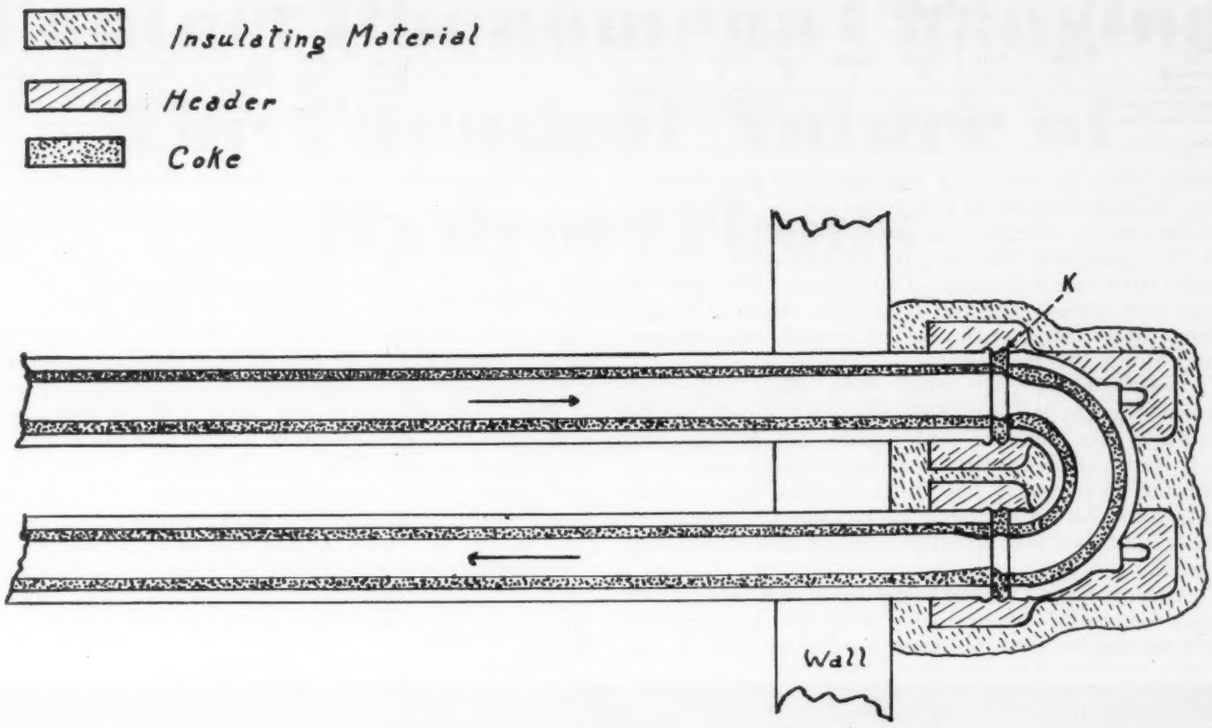


FIGURE 1

In this sketch, which shows application of insulation to a header, attention is called to point K. Here a small cavity in the header and return bend, permits expansion to take place and thus increase coke formation. No method has been found to overcome this.

On Stream Time Increased By Insulating Headers And Return Bends

B. G. ADAMS, Chief Chemist
El Tejon Oil & Refining Corporation

EVERY refiner desires longer cracking-still runs and many have undertaken experiments in an effort to determine the cause of too frequent shutdowns for coke clean-out. A few have been successful but it is doubtful that any other solution has been found as effective and simple as that adopted at the Bakersfield, California, plant of El Tejon Oil & Refining Corporation. By insulating headers and return bends of the cracking-still furnace on-stream time for the cracking units was increased 25 percent.

A few steps in the study of this case are worthy of discussion, while a brief description of plant operating conditions will furnish the differentials necessary to make the data applicable to other systems.

Crude oil from which gasoline and kerosene have been removed is charged through the heat exchangers into the side of an evaporator, where the fuel oil is dropped and the gas oil is vaporized by the heat and mixed with the discharge from the still which enters the bottom of the evaporator. This vapor passes out the top of the evaporator and into the side near the bottom of the fractionating tower. The gasoline is taken off overhead and the hot-oil-charging pump to the still takes suction from the bottom of the tower. The 22-API-gravity gas oil is pumped to the still at 650° F., pressure 800 pounds per square inch, velocity 190 barrels per hour through 2-inch tubes. At the outlet these figures are: 935° F., 490 pounds per square inch, 190 barrels per hour.

The first problem was to determine the cause of erratic coking, since some runs were twice as long as others. It was found that although there was no appreciable variation in gravity of the gas oil charge to the still, some samples were much darker than the average. This was caused by a surge in the evaporator when it was overloaded, a condition which allowed a small amount of fuel oil to pass out with the gas oil. When this fuel oil was subjected to the temperature and pressure necessary to crack the gas oil, rapid decomposition took place with the resultant

TABLE 1

Beginning	Dec. 1	Feb. 1	April 1	June 1	Aug. 1	Oct. 1	Dec. 1
Length of run–hrs..	700	690	707	720	722	706	700
Barrels Gasoline...	13,800	13,500	14,400	15,100	15,800	15,000	14,200

coking. This trouble was corrected by installing a more suitable float level controller on the evaporator and frequently checking on samples for color.

After equalizing the lengths of operating periods, longer runs were sought. The figures arranged in Table 1 revealed that the time was slightly longer during the warm months so the search was concentrated along thermal lines.

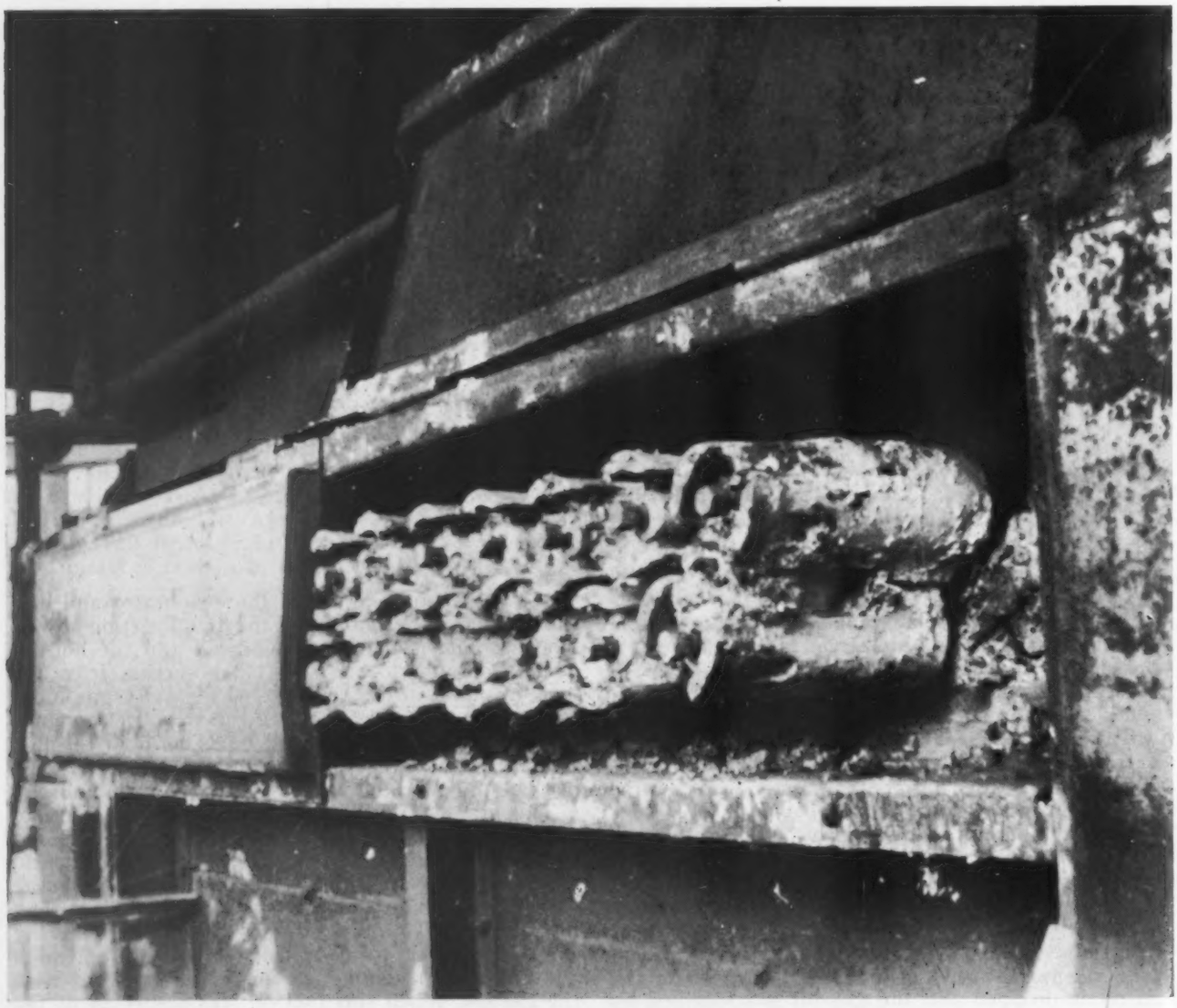
It was evident that much heat was being lost through the header box. This loss was minimized by insulating the headers and return bends with the result that on-stream time for the cracking units was increased 25 percent (see Table 2). Chilling at these points and the subsequent deposition of coke here and in the tubes was greatly reduced and its density diminished.

Deviation from the still's designed conversion per pass, a function of the velocity, distance, temperature and pressure, results in either smaller yield of desirable products and or increased coke formation. The latter is accelerated by lengthening the time of cracking which will occur if the oil, in variation with atmospheric changes, is cooled at each return bend. Also this condition is not congruent with some engineer's contention that the most effective cracking is accomplished by a steady increase in temperature.

TABLE 2

	Avg. Run Time Hrs.	Avg. Gaso. Yield Per Hr.	Clean-out Time	Inlet Pressure Begin	Inlet Pressure End	Outlet Pressure
No Insulation.....	708	20.7	16	775	825	490
Insulated.....	910	23.0	12	775	810	490

The insulating material used was of the plastic type. Its cost is negligible and application and removal are simple. The wet plastic is packed, about two inches thick, around each header. The installation illustrated is equipped with a hinged door header box which has been opened following a shut-down. The insulation has been partially removed. For about an hour, before opening, steam was introduced into the header box reducing the hardened insulation to mastic.



Here the insulating material has been reduced to mastic by application of steam, the procedure preliminary to tube cleaning. Each header bank is equipped with a hinged door.

Contact Phenomena Changing The Chemical Nature of Hydrocarbons

N. D. ZELINSKII

Trudy Sessii Akademii Nauk, U.S.S.R. po Organicheskoi Khimii (Transactions of the Organic Chemistry Session of the Academy of Sciences of U.S.S.R.) December, 1936. Published by the Academy of Sciences U.S.S.R., Moscow-Leningrad, 1939, 318 pages; pp. 5-24. Translated by J. G. Tolpin, Survey of Foreign Petroleum Literature, Universal Oil Products Company.

ABSTRACT

RESEARCH on catalytic reactions carried out by N. D. Zelinskii and his co-workers is reviewed. Formation of intermediate compounds composed of the reactants and the catalyst is not a necessary prerequisite for a catalytic reaction. The catalyst changes the dynamic properties and the form of the molecules and thus accelerates their interaction. The destructive action of nickel catalysts can be prevented by depositing nickel on alumina. Cyclohexanes are distinguished by their selective dehydrogenation to aromatics, which is not observed in the case of other naphthenes. The phenomenon of irreversible catalysis consists in redistribution of the hydrogen of cyclohexenes with formation of naphthenes and aromatics. In bi- and tricyclic hydrocarbons five-member rings can withstand hydrogenation and dehydrogenation, while three and four-member rings are decomposed. However, cases are listed in which cyclopentanes also undergo a scission of their ring in hydrogenation over platinum. Cyclization of isoparaffins, of a paraffin chain connecting two naphthene rings and aromatization by conversion of a cyclopentane into a cyclohexane followed by dehydrogenation of the latter are cited. Contact with platinum or palladium may effect a shift of the double bond of olefins or stereoisomerization.

This translation has been submitted by the Petroleum Division of the American Chemical Society. The Petroleum Division, however, assumes no responsibility for the facts and opinions presented in this article.

The introductory part of the original manuscript has been condensed and the remainder literally translated.

CATALYTIC reactions are only a special case of contact processes of general significance. Contact takes place in each catalytic process; however, in a number of cases the results of the reaction cannot be interpreted by assuming formation of temporary intermediate compounds, the composition of which necessarily includes the catalyst. Catalytic hydrogenation, dehydrogenation and irreversible catalysis of six-member ring systems should be discussed mainly from the point of view of the effect of contact on the course of chemical conversions. In the conception of D. I. Mendeleev[1] the mechanism of catalysis does not require formation of intermediate products, but depends upon the strain in the chemical system required for the chemical reaction and acquired in contact with another body at ordinary or somewhat elevated temperature. Changes of the dynamical properties of molecules and of their forms in the process of catalysis are beyond doubt; they are the main cause of origination and of the course of catalytic reactions. Deformation of molecules takes place under the action of the field of force developed by the active surface of the catalyst, affecting the configuration of the particles and preparing these particles for interaction. This effect is so high and the deformation may be so powerful that beyond the limits of comparatively low temperatures the molecules become overstrained which leads to their decomposition. Thus the surface energy of the contact substance produces a deep change in the chemical nature of the molecules that come in contact with the catalyst, and even destroys them.

Experimental investigations in the field of catalysis gradually formed in the author's mind a conception that in many catalytic reactions, formation of intermediate temporary forms is not essential and that these are not *conditio sine qua non* for the catalysis. Further work on catalysis in the presence of metals and their oxides strengthened the idea that it is not intermediate forms or hydrides of these metals that are of decisive importance; rather is it the extent of dispersion of the catalyst and its surface energy that change the dynamic character and the form of molecules accelerating the interaction between them.

At high temperatures over 250° C. the surface energy of the metallic catalyst is usually so high that the decomposition of particles in contact with it begins to prevail over the theoretically expected normal course of the reaction. This takes place, for instance, when nickel is used as a catalyst instead of platinum or palladium. The most acceptable catalyst is that which accelerates the process in a definite direction, but does not raise the dynamic state of particles to an extent at which their deep and complete decomposition takes place.

Although we are still far from knowledge of the nature of catalysis in its entirety and its various manifestations, and the specific part played by the catalyst is yet little understood, its rôle, nevertheless, appears wih exceptional clarity in the field of organic compounds, where selective catalysis may be spoken of with complete justification. The contact phenomena taking place in hydrocarbons of definite structure closely resembles enzymatic biochemical

processes, the specific nature of which is clearly expressed.

Contact reactions changing the chemical nature of hydrocarbons were shown by the author's investigations to be most clearly expressed when platinum, palladium or closely resembling these in their action iridium, rhodium and osmium are used in heterogeneous catalysis of six-member ring systems. Nickel and ruthenium[2] are less suitable for this purpose since at temperatures over 250° C. their surface energy exerts a destructive effect on particles that come in contact with them. The author's research clearly established for the first time that this undesirable effect of nickel as a catalyst can be largely prevented by depositing it on aluminum oxide.[3] In this case its surface energy level is reduced, and its contact with organic molecules is not accompanied by their extensive decomposition. In this form the nickel catalyst approaches in its effect platinum and palladium. The energy of activation on this catalyst is 12,300 calories per mol. It was found by the author that the energy of activation and the temperature coefficient of the reaction velocity depend not upon the nature of the reacting substance but upon the nature of the catalyst used.[4]

This type of nickel catalyst achieved recognition in the course of years and is being widely used for catalytic hydrogenation and dehydrogenation. Apparently aluminum oxide separates and preserves the active centers on the surface of the nickel catalyst, combining them in a regular fashion, due to which its activity is preserved for a long time; this constitutes its advantage over the Sabatier catalyst.[5]

The research reported below was started when it was established that only the six-member naphthenes undergo catalytic dehydrogenation in the presence of platinum and palladium at low temperature (170° C.) and are converted into aromatics.[7] Ring systems with 4, 5 and 7 carbon atoms do not undergo this reaction.[6] Without contact with these metals the stability of cyclohexane is so high that even at 550-600° C. it does not undergo dehydrogenation. It is highly puzzling why only hydrocarbons containing the six-member ring lose hydrogen with such facility.

1. Selective Catalysis

When an equimolecular mixture of two isomeric hydrocarbons, cyclohexane and methylcyclopentane is subjected to catalytic dehydrogenation, it is found that cyclohexane is completely converted into benzene, while methylcyclopentane remains entirely unchanged. This selective catalysis was first observed by the author and is being employed as a new reliable method of determination of the chemical nature of cyclic compounds of natural petroleum. The selective catalysis may generally be expressed as follows:

$$C_6H_{11}R \xrightarrow[300^\circ \text{ in a stream of } CO_2]{\text{Pt, Pd}} C_6H_5R + 3H_2$$

$$C_5H_9R \xrightarrow[300^\circ \text{ in a stream of } CO_2]{\text{Pt, Pd}} \text{No change}$$

The substituted cyclohexane is seen to lose in the catalytic process six hydrogen atoms and to be converted into an aromatic hydrocarbon. However, its substituted isomer, the cyclopentane hydrocarbon is stable under these conditions and liberates no hydrogen. The same stability with regard to catalytic dehydrogenation distinguishes hydrocarbons with four or seven carbon atoms. Thus, the experiment indicates the exclusive ability of six-member rings to complete dehydrogenation. The method of contact dehydrogenation may thus be used to isolate from a mixture of different ring systems, cyclohexane and its derivatives, converting them into benzene and its homologs.

2. Irreversible Catalysis

In investigations of the reaction of cyclohexane to contact with platinum or palladium it was established[8] that redistribution of hydrogen atoms takes place between the incompletely hydrogenated six-member rings. The following examples are characteristic of this catalysis. In the vapor phase (80-100° C.) cyclohexene in contact wtih platinum liberates no hydrogen, but is completely and rapidly converted into cyclohexane and benzene. This process takes place at ordinary temperature, but at a low rate. It was termed by the author "irreversible catalysis" because there is no catalyst that can convert an equimolecular mixture of benzene and cyclohexane into cyclohexene.

An interesting behavior toward contact is displayed by cyclohexadiene.[9] Both its isomers (1, 3- and 1, 4-) are instantaneously converted in contact with platinum or palladium into cyclohexene and benzene, the reaction resembling an explosion. The thermal effect of this conversion is about 7700 calories per mol. The further conversion of cyclohexene into cyclohexane and benzene takes place with a lower velocity.

Unlike benzene, the cyclohexadiene molecule is in a strained labile state that can be disturbed by simple contact with the above-mentioned metals. The author kept for over 20 years a preparation of cyclohexadiene in a sealed tube. It preserved all its original physical constants, and it cannot be assumed that even a small part of cyclohexadiene underwent during this comparatively long period irreversible catalysis spontaneously.

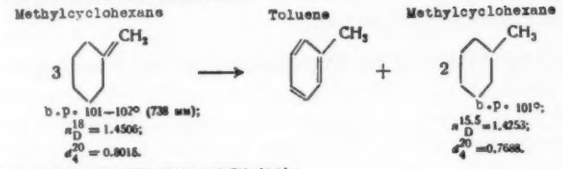
Hydrocarbons with a semicyclic double bond. Of these hydrocarbons, methylenecyclohexane also easily and rapidly undergoes irreversible catalysis under the above indicated conditions. The mechanism of this reaction may be theoretically conceived as follows: at the first moment of the contact of this hydrocarbon with platinum, it is isomerized into methylcyclohexene by displacement of the semicyclic double bond into the ring. The newly formed methylcyclohexene is further converted into toluene and methylcyclohexane. It will be shown later that more complex derivatives of cyclohexane with side chains having one or two double bonds behave similarly and shift these bonds into the ring under the action of the contact substance, the side chains becoming saturated in character.

Continued research in this direction required experiments with condensed bicyclic unsaturated hydrocarbons. In order to determine which of them will suffer irreversible catalysis at temperatures not over 200° C. in contact with platinum or palladium, dihydronaphthalene and octahydronaphthalene were used. Both were found to be easily converted into naphthalene and tetrahydronaphthalene, or into naphthalene and decahydronaphthalene, respectively. Dihydronaphthalene undergoes irreversible catalysis already at room temperature, although slowly.

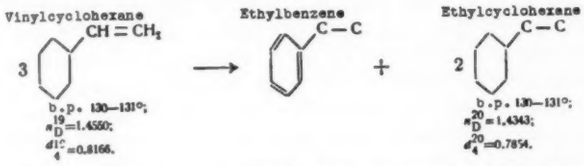
Bicyclic hydrocarbons with a bridge.[15] Of these the following were investigated: carane, pinene, nopinene and α-fenchene. The first three contain in their system a trimethylene and tetramethylene ring and are easily converted at temperatures not exceeding

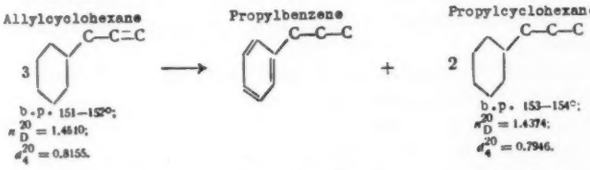
IRREVERSIBLE CATALYSIS

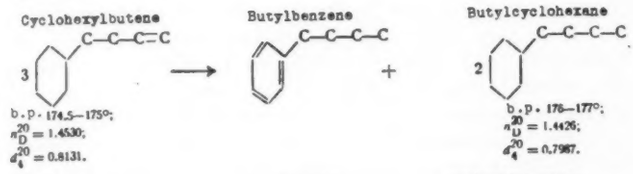
SEMICYCLIC DOUBLE BOND (10):

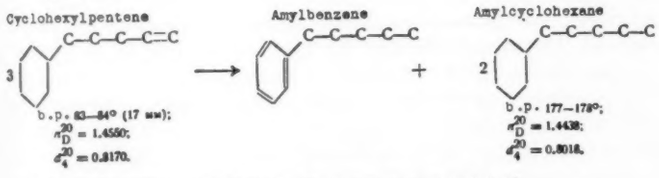


DOUBLE BOND IN THE SIDE CHAIN (11):

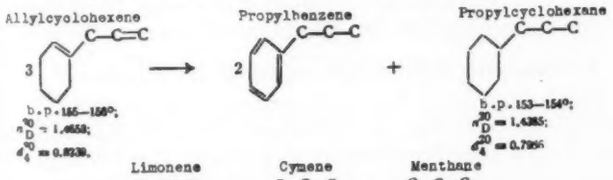


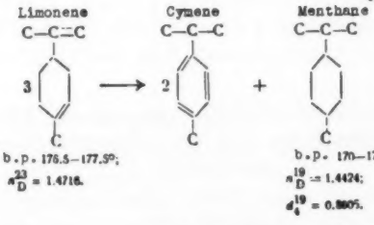


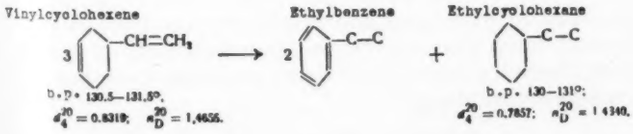




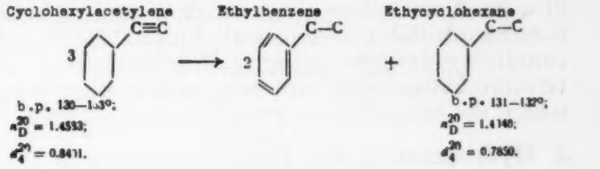
TWO DOUBLE BONDS, ONE OF WHICH IS IN THE SIDE CHAIN (12):

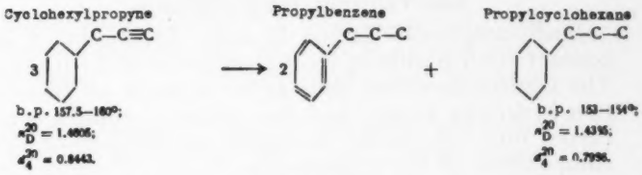


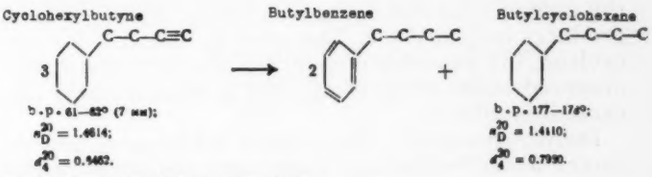




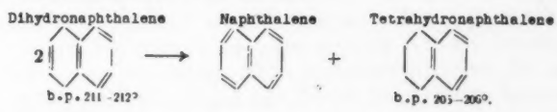
TRIPLE BOND IN THE SIDE CHAIN (13):

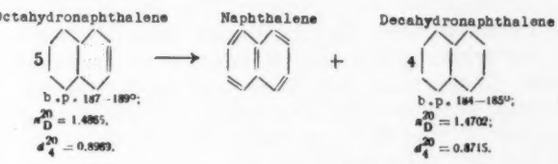




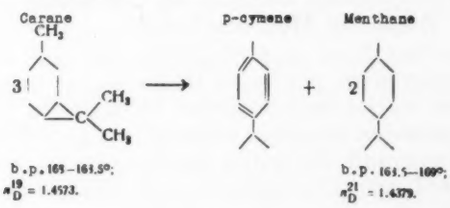


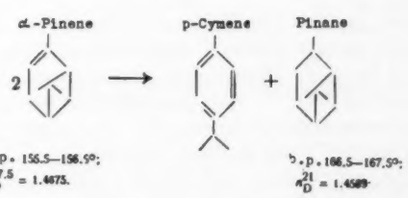
BICYCLIC CONDENSED HYDROCARBONS (14):

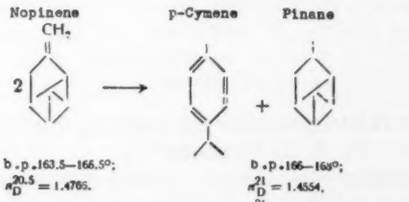


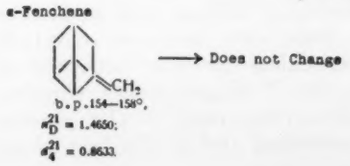


BICYCLIC HYDROCARBONS WITH A BRIDGE (15):









200° C.: carane is converted into p-cymene and menthane, while pinene and nopinene are converted into p-cymene and pinane. ∝-Fenchene does not change in contact with platinum or palladium. This is undoubtedly due to the presence in this bicyclic system of a pentamethylene ring, which is more stable and is not ruptured. Consequently, bicyclic hydrocarbons containing bridges forming a trimethylene and a tetramethylene ring are less stable than those in which the bridge forms a pentamethylene ring.

3. Hydrogenation and Dehydrogenation of Bicyclic and Tricyclic Hydrocarbons

Hydrogenation.[16] Carane is easily hydrogenated in contact with platinum in the presence of hydrogen. The trimethylene ring adds at the moment of rupture two hydrogen atoms, and the carane is totally converted into menthane. A similar mechanism of decomposition of the trimethylene ring is observed in the case of cyclofenchene, which adds hydrogen and produces isobornylane. The same is true also for tricyclene, the conversion of which into camphane was observed under these conditions at temperatures not exceeding 200° C.

Dehydrogenation.[16] The contact dehydrogenation of carane at 300° C. brings about decomposition of the trimethylene ring and formation of only p-cymene. Depending upon the carbon atoms between which the rupture occurs, pinane may be converted in the process of dehydrogenation into either of the two fractions of cymene, of which the higher boiling (173-175° C.) corresponds to p-cymene. The same is true also for cyclofenchene that produces upon the rupture of the trimethylene ring a mixture of isomeric fenchenes. Concerning fenchane and isobornylane, their bicyclic system contains a pentamethylene ring and because of this it is so stable that it does not undergo contact dehydrogenation.

4. Dehydrogenation Leading to Condensed Aromatic Hydrocarbons[17]

Dicyclohexylmethane and dicyclohexylethane liberate in contact with platinum 12 hydrogen atoms from the two cyclohexyl radicals; in addition the cyclohexyls combine by elimination of two additional hydrogen atoms, and the initial forms are converted into condensed aromatic systems of fluorene and phenanthrene.

Consequently, under conditions of catalytic dehydrogenation, the newly formed diphenylmethane and diphenylethane tend to liberate at the comparatively low temperature of 300° C. two more hydrogen atoms each, forming condensed aromatic systems. Such condensed aromatic systems are known to form in pyrogenetic decomposition and condensation of complex and simple organic compounds. The research of the author shows that under contact conditions, a temperature of 300° C. is sufficient for the conversion of the above named hydrocarbons into condensed polynuclear aromatic forms.

5. Catalytic Hydrogenation of 2-Methylbicyclo-(1, 2, 2)-Heptane[18]

This hydrocarbon possesses an endo-methylene group and thus consists of two connected pentamethylene rings. It was previously shown that at 300° C. methylbicycloheptane does not undergo catalytic dehydrogenation, as revealed by the behavior of fenchane and isobornylane.[16] Experiments showed, however, that the hydrocarbon used in the present study was easily hydrogenated and in the first phase of its conversion added two hydrogen atoms producing a mixture of substituted cyclopentanes of the composition C_8H_{16}. In the second phase this mixture adds two more hydrogen atoms and is totally converted into a mixture of isoparaffins. Consequently the bicyclic system of the initial hydrocarbon underwent a complete scission and was entirely saturated with hydrogen. In other words, the two cyclopentane rings of methylbicycloheptane cannot withstand the action of hydrogen under conditions of contact with platinum and consecutively undergo a rupture with addition of hydrogen. In the absence of hydrogen no change is observed.

6. Hydrogenation of Cyclopentane and its Homologs[19]

In view of the above reported results the experiments of contact hydrogenation were extended to cyclopentane and its homologs in order to verify the behavior under similar conditions of one of the most stable monocyclic systems which is entirely free of strains in the carbon atoms composing it. According to the classical theory of A. Baeyer, cyclopentane should be the most stable ring system. However, it was found that cyclopentane as well as its closest homologs in contact with platinum do not withstand the effect of hydrogen and the ring is opened adding hyrogen in a manner resembling unsaturated hydrocarbons.

The further studies on contact rupture and hydrogenation of pentamethylene rings led to investigation of bicyclopentyl.[20] The following conversions of this hydrocarbon took place upon passing it several times over platinum in the presence of hydrogen. In the first step one ring is opened with addition of hydrogen, and amylcyclopentane is formed. Further the second ring is also opened, and a mixture of isomeric decanes ($C_{10}H_{22}$) is formed from amylcyclopentane. Simultaneously another conversion takes place: the ring of amylcyclopentane is widened by addition of 1 carbon atom taken from the amyl radical, butylcyclohexane is formed which is dehydrogenated with formation of butylbenzene. Among the products of contact conversion of bicyclopentyl the aromatic hydrocarbon is found indicating the extent of change of the chemical nature of the hydrocarbon under the conditions used. The work with bicyclopentyl is being continued in order to isolate larger quantities of the products of its conversion.

7. Catalytic Dehydrogenation of Hydrindane[21]

The behavior of the cyclopentane ring in this condensed system was investigated. At 300-330° C. it was found that hydrindane first loses six hydrogen atoms producing hydrindene which further suffers a rupture of the cyclopentane ring forming o-methylethylbenzene.

8. Conversion of Phenylcyclopentane, Phenylcyclopentylmethane and Cyclohexylcyclopentylmethane[22]

These dicyclic compounds also undergo rupture and hydrogenation of the pentamethylene ring in the presence of hydrogen and platinum; amylbenzene is formed from phenylcyclopentane, and hexylbenzene from phenylcyclopentylmethane and from cyclohexylcyclopentylmethane.

9. Catalytic Hydrogenation of ∝-Naphthylcyclopentane[23]

Scission of the pentamethylene ring accompanied by its hydrogenation in the presence of platinum is

HYDROGENATION AND DEHYDROGENATION OF BICYCLIC AND TRICYCLIC HYDROCARBONS.(16)

Carane → Menthane (+H_2)

b.p. 168—168.5°; $n_D^{19} = 1.4573$.

b.p. 164.5—169°; $n_D^{22} = 1.4394$; $d_4^{22} = 0.7985$.

Cyclofenchene → Isobornylane (+H_2)

b.p. 143°; $n_D^{20} = 1.4525$; $d_4^{20} = 0.8614$.

b.p. 162—163°; $n_D^{20} = 1.4577$; $d_4^{20} = 0.8566$.

Tricyclene → Camphane (+H_2)

m.p. 66°.

m.p. 151°.

Carane → p-Cymene (+$2H_2$)

b.p. 163—164.5°; $n_D^{24} = 1.4551$.

b.p. 174.5—175°; $n_D^{21} = 1.4858$; $d_4^{21} = 0.8552$.

Pinane → Cymene

b.p. 167—167.5°; $n_D^{21} = 1.4605$; $d_4^{20} = 0.8521$.

[Two Fractions
1) 170—173°; $n_D^{20} = 1.4906$;
2) 173—175°; $n_D^{20} = 1.4904$; $d_4^{20} = 0.8597$]

Cyclofenchene → Mixture of fenchenes

b.p. 143°; $n_D^{20} = 1.4525$; $d_4^{20} = 0.8504$.

[Two fractions
1) 143—154°: $n_D^{20} = 1.4540$
2) 154—156°: $n_D^{20} = 1.4603$]

β-Fenchene b.p. 151—153°. + d-Fenchene b.p. 154—156°.

Rupture Between 4 & 5 and 4 & 3

Fenchane and Isobornylane → Do not change

Fenchane: b.p. 149°; $n_D^{18} = 1.4474$.

Isobornylane: b.p. 162—163.5°; $n_D^{19.5} = 1.4559$.

DEHYDROGENATION PRODUCING CONDENSED AROMATIC HYDROCARBONS (17)

Dicyclohexylmethane → Fluorene (Pt, 300°, +$7H_2$)

b.p. 250—252°; $n_D^{20} = 1.4752$; $d_4^{20} = 0.9750$.

m.p. 116°.

Dicyclohexylethane → Phenanthrene (Pt, 300—310°, +$7H_2$)

b.p. 272—273°; $n_D^{24} = 1.4745$; $d_4^{24} = 0.8728$.

m.p. 99°

HYDROGENATION OF 2-METHYLBICYCLO-(1,2,2)-HEPTANE (18)

b.p. 124.5—126° (745 mm); $n_D^{16.5} = 1.4553$; $d_4^{16.5} = 0.8561$

Pt [+ H_2], 305° → C_8H_{16} Mixture of Substituted Cyclopentanes b.p. 111—118°; $n_D^{20.5} = 1.4194$; $d_4^{20.5} = 0.7502$.

[+ H_2] → C_8H_{18} Mixture of Isoparaffins b.p. 104—111°; $n_D^{20.5} = 1.4116$.

HYDROGENATION OF CYCLOPENTANE AND ITS HOMOLOGS (19)

	Initial Hydrocarbon	48.5 — 51°	$n_D^{15} = 1.4101$	$d_4^{15} = 0.7490$
	Product of Catalysis	35.5 — 37°	$n_D^{21.5} = 1.3608$	$d_4^{21.5} = 0.6245$
	n-Pentane	36 — 37°	$n_D^{13} = 1.3606$	$d_4^{21.5} = 0.6217$
	Initial Hydrocarbon	71 — 72.5°	$n_D^{15} = 1.4119$	$d_4^{15.5} = 0.7505$
	Product of Catalysis	60 — 63°	$n_D^{16.5} = 1.3770$	$d_4^{15.5} = 0.6606$
CH_3	2-Methylpentane	60 — 61°	$n_D^{15} = 1.3735$	$d_4^{20} = 0.6608$
	Initial Hydrocarbon	100.5 — 101.5°	$n_D^{20} = 1.4202$	$d_4^{20} = 0.7654$
	Product of Catalysis	91 — 96°	$n_D^{19} = 1.3932$	$d_4^{19} = 0.6967$
C_2H_5	2-Methylhexane	90.2°		$d_4^{15} = 0.6842$
	Initial Hydrocarbon	126 — 128°	$n_D^{15.5} = 1.4270$	$d_4^{16.5} = 0.7789$
	Product of Catalysis	117 — 119°	$n_D^{17.5} = 1.4045$	$d_4^{17.5} = 0.7177$
C_3H_7	4-Methylheptane	118°	$n_D^{15} = 1.3978$	$d_4^{15} = 0.7217$

BICYCLOPENTYL (20)

b.p. 188 — 188.4° (741 mm); $n_D^{23} = 1.4440$; $d_4^{23} = 0.8634$

+ H_2 → C_5H_{11} b.p. 170 — 172° (749 mm); $n_D^{21.6} = 1.4348$; $d_4^{21.6} = 0.7849$

$C_{10}H_{22}$ b.p. 155—169°; $n_D^{22} = 1.4290$.

C_4H_9, C_4H_9 [$-3H_2$] b.p. 185—195°; $n_D^{18} = 1.4503$.

CATALYTIC DEHYDROGENATION OF HYDRINDANE (21)

Hydrindane → Hydrindene (Pt [− $3H_2$], 300—320°)

b.p. 164.5 — 165°; $n_D^{20} = 1.4698$; $d_4^{20} = 0.9473$.

Hydrindene → o-Methylethylbenzene (Pt [+ H_2], 300—320°)

b.p. 176 — 177°; $n_D^{20} = 1.5389$; $d_4^{20} = 0.9633$.

o-Methylethylbenzene: b.p. 164 — 165°; $n_D^{20} = 1.5063$; $d_4^{20} = 0.8873$.

HYDROGENATION OF PHENYLCYCLOPENTANE, PHENYLCYCLOPENTYLMETHANE AND CYCLOHEXYLCYCLOPENTYLMETHANE. (22)

Phenylcyclopentane → n-Amylbenzene (Pt [+ H_2], 305—310°)

b.p. 216—218° (750 mm); $n_D^{19} = 1.5296$; $d_4^{19} = 0.9509$.

n-Amylbenzene: b.p. 200—202° (750 mm); $n_D^{19} = 1.4920$; $d_4^{19} = 0.8665$.

Phenylcyclopentylmethane → n-Hexylbenzene (Pt [+ H_2], 300—310°)

b.p. 234—236° (750 mm); $n_D^{21} = 1.5170$; $d_4^{21} = 0.9283$.

n-Hexylbenzene: b.p. 218—221° (750 mm); $n_D^{20} = 1.4940$; $d_4^{20} = 0.8631$.

Cyclohexylcyclopentylmethane → n-Hexylbenzene (Pt [− $2H_2$], 300—310°)

b.p. 224—226° (750 mm); $n_D^{23} = 1.4671$; $d_4^{23} = 0.8721$.

n-Hexylbenzene: b.p. 218—221° (750 mm); $n_D^{19} = 1.4960$; $d_4^{19} = 0.8712$.

observed also in this case, and amylnaphthalene results. Simultaneously a more extensive decomposition of the pentamethylene ring takes place and an ethylene fragment is liberated producing a condensed three-ring system, peri-trimethylenenaphthalene. This could take place also by elimination of ethane from the side chain of α-amylnaphthalene.

10. Contact Aromatization of Gasolines at the Expense of Cyclohexanes[24]

The selective catalysis leading to aromatization of six-member cyclic compounds in contact with platinum, palladium or nickel on alumina constitutes a reliable method of production of aromatic hydrocarbons from gasoline fractions of natural oil. The research of the author showed that gasoline fractions from different crude oils contain different amounts of cyclohexanes. In Surakhany, Balakhany and Emba oils (Kos-Chagyl field) cyclohexanes are very abundant. For instance, aromatization of Surakhany gasoline gave the following results:

		Aromatics, % by volume	
Boiling range	Catalyst	Before Catalysis	After Catalysis
75-105° C.	Ni on Al_2O_3	1	52.6
100-102° C.	The same	1	65
120-124° C.	Pt on carbon	1.5	55.6

It was further found that aromatization of gasolines, especially in the presence of nickel on aluminum oxide at temperatures over 300° C., namely 330-350° C., gives products with unusually high contents of aromatics that reach in some experiments 84 percent. This is explained by secondary aromatization occurring under these conditions; after dehydrogenation of all cyclohexanes, extensive isomerization and further cyclization of cyclopentanes and paraffins always contained in the oil fractions takes place. The platinum catalyst deposited on activated carbon first completes the aromatization of all six-member rings, after which it also causes at 300° C. cyclization of a considerable portion of paraffins into cyclohexanes and converts the latter into aromatics. The author has been able to definitely establish that as a rule cyclization and aromatization of paraffins and not only dehydrogenation of cyclohexanes takes place in catalytic aromatization of gasoline-ligroin fractions under the action of the platinum catalyst. In the investigation of gasolines it was found that the extent of aromatization of paraffins fluctuates, depending upon the chemical nature of the fractions, between 16 and 62 percent.

11. Aromatization of Cyclopentanes and Paraffins[25]

In the investigation of the rupture of the ring system of normal butylcyclopentane under the influence of the catalyst, it was observed that along with formation of isononanes (C_9H_{20}) isomerization of butylcyclopentane into propyl- and methylethylcyclohexane also takes place, and these undergo dehydrogenation leading to their conversion into propyl- and o-methylethylbenzene. Under the same conditions platinum effects at 300-350° C. a substantial conversion of diisobutyl (C_8H_{18}) into p-xylene. Normal octane is converted into o-xylene and ethylbenzene. Diisoamyl similarly gives m-cymene. These data show that substituted cyclopentanes and paraffins can be isomerized in contact with platinum into cyclohexanes under comparatively mild temperature conditions, the cyclohexanes being dehydrogenated to aromatics at the moment of their formation.

12. Dehydrogenation of 2-Methylbicyclo-(2, 2, 2,)-Octane[26]

In this hydrocarbon the bridge consisting of 2 methylene groups connects two carbon atoms of the hexamethylene ring in para position. This bicyclic condensed system of two hexamethylene rings eliminates in contact dehydrogenation the bridge in the form of ethylene together with 4 hydrogen atoms, and toluene is formed. Simultaneously a deeper decomposition of this hydrocarbon takes place resulting in formation of propene and benzene.

13. Contact Decomposition of Cyclopentanes by Hydrogen From Cyclohexanes[27]

A mixture of cyclohexane and ethylcyclopentane was dehydrogenated over platinum at 305° C. The hydrogen liberated from the cyclohexane in statu nascendi was found to convert a considerable part of ethylcyclopentane into heptane (C_7H_{16}).

14. Isomerization of α,β-Olefins[28]

Open chain hydrocarbons. 2, 6-dimethyl-7-octene is isomerized in contact with palladium at 200° C. into 2, 6-dimethyl-6-octene. Diallyl in contact with platinum produces at 200-300° C. a mixture containing 73.4 percent dipropenyl.

Aromatics with double bond in the side chain. Allylbenzene is isomerized into propenylbenzene in contact with platinum at 300° C. Allytoluene produces under the same conditions a mixture containing up to 84 percent propenyltoluene; v-butenylbenzene similarly forms at 300° in contact with platinum β-butenylbenzene.

15. Stereoisomeric Conversion[29]

Dimethyl ester of maleic acid in contact with palladium at 205° is completely isomerized into the dimethyl ester of fumaric acid. Cis-dimethylcyclohexane is isomerized into trans-dimethylcyclohexane in contact with nickel at 175° C. o-Dimethylbenzene, when hydrogenated in the presence of osmium at 50-70° C., produces cis-dimethylcyclohexane. However, when hydrogenated over nickel it gives trans-dimethylcyclohexane.

16. Contact Dissociation and Synthesis[30]

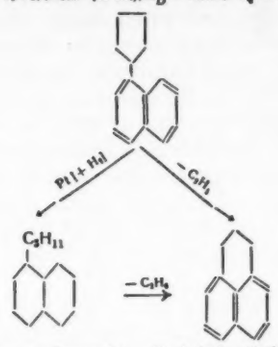
It is known from the work of Sabatier and Senderens that cyclohexane undergoes in an atmosphere of hydrogen at 280° C. not only dehydrogenation, but complete decomposition to methane. However, when cyclohexane is passed at 300-350° C. over nickel on aluminum oxide in a stream of hydrogen, dehydrogenation to benzene and decomposition to methane is accompanied also by formation of considerable quantities of hydrocarbons boiling much higher than benzene. The fraction boiling at 105-110° C. was found to be quite close to toluene and its exhaustive bromination in the presence of aluminum bromide gave pentabromotoluene melting at 283° C. The fraction boiling at 130-140° C. was found to consist mostly of xylene that contained also dimethylcyclohexane. Its bromination produced tetrabromo-p-xylene melting at 256° C. The gaseous products contained only methane and hydrogen.

This experiment leaves no doubt that cyclohexane undergoes under these conditions not only complete decomposition to methane, but also a synthetic process. The mechanism of formation of toluene, xylene and dimethylcyclohexane from cyclohexane is

HYDROGENATION OF α-NAPHTHYLCYCLOPENTANE (23)

α-Naphthylcyclopentane

b.p. 174–175° (12 mm); $n_D^{17} = 1.6091$; $d_4^{17} = 1.0432$



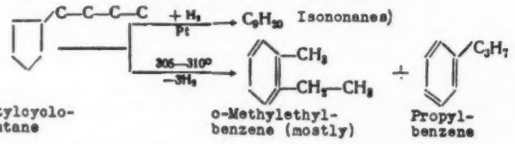
Mixture of Isomeric α-amylnaphthalenes

b.p. 155–160° (12 mm); $n_D^{17} = 1.5790$; $d_4^{17} = 1.0121$.

Peri-trimethylene-naphthalene

b.p. 172–178 (17 mm); m.p. 68–68.5°.

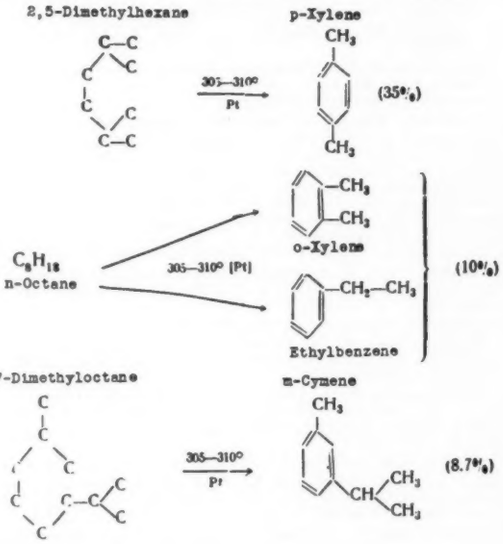
AROMATIZATION OF CYCLOPENTANES AND PARAFFINS (25)



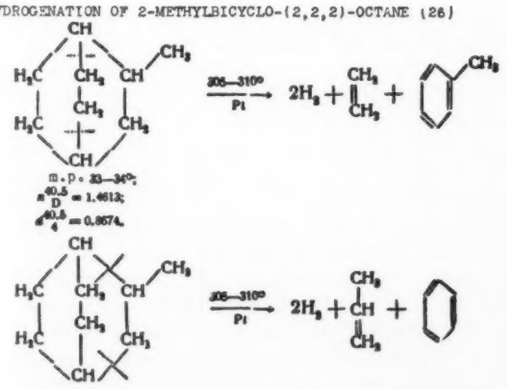
n-Butylcyclo-pentane

o-Methylethyl-benzene (mostly)

Propyl-benzene

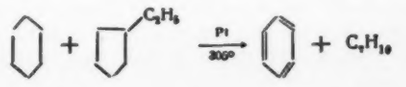


DEHYDROGENATION OF 2-METHYLBICYCLO-(2,2,2)-OCTANE (26)



m.p. 33–34°; $n_D^{40.5} = 1.4613$; $d_4^{40.5} = 0.8674$.

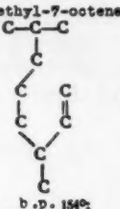
DECOMPOSITION OF A FIVE-MEMBER RING BY THE HYDROGEN OF A CYCLOHEXANE (27)



CONTACT ISOMERIZATION OF UNSATURATED HYDROCARBONS WITH A DOUBLE BOND IN α,β-POSITION (28)

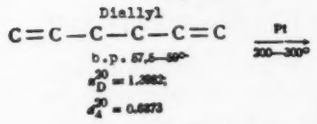
2,6-Dimethyl-7-octene

b.p. 154°; $n_D^{20} = 1.4312$; $d_4^{20} = 0.7396$.



2,6-Dimethyl-6-octene

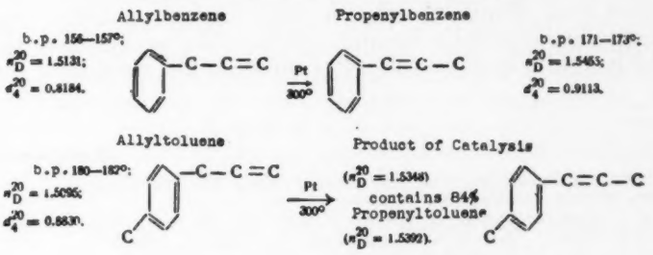
b.p. 161°; $n_D^{25} = 1.4259$; $d_4^{25} = 0.7432$.

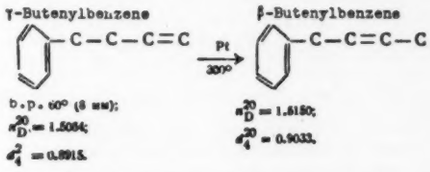


b.p. 67.5–69°; $n_D^{20} = 1.2682$; $d_4^{20} = 0.6873$

b.p. 68–80°; $n_D^{20} = 1.4396$, contains 73.4% 2,4-Hexadiene

AROMATICS WITH DOUBLE BOND IN THE SIDE-CHAIN

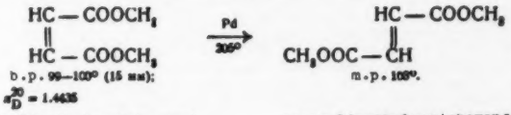




b.p. 60° (8 mm); $n_D^{20} = 1.5084$; $d_4^{20} = 0.8915$.

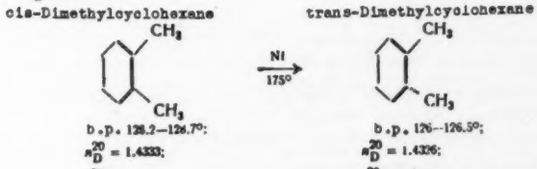
$n_D^{20} = 1.5150$; $d_4^{20} = 0.9033$.

CONTACT STEREOISOMERIC CONVERSIONS (29)



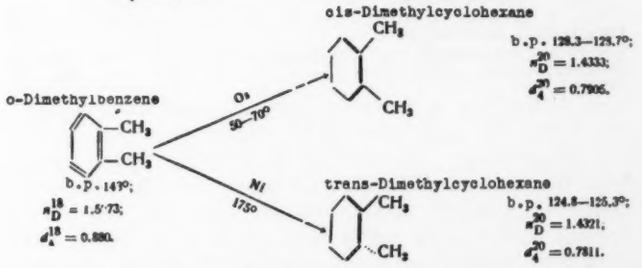
b.p. 99–100° (15 mm); $n_D^{20} = 1.4435$

m.p. 168°.



b.p. 128.2–128.7°; $n_D^{20} = 1.4333$; $d_4^{20} = 0.7905$.

b.p. 126–126.5°; $n_D^{20} = 1.4326$; $d_4^{20} = 0.7823$.

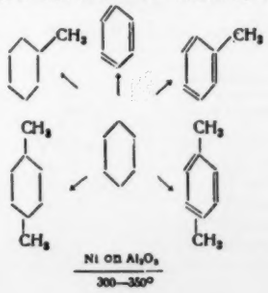


b.p. 128.3–128.7°; $n_D^{20} = 1.4333$; $d_4^{20} = 0.7905$.

b.p. 143°; $n_D^{18} = 1.5073$; $d_4^{18} = 0.880$.

b.p. 124.8–125.3°; $n_D^{20} = 1.4321$; $d_4^{20} = 0.7811$.

DISSOCIATION AND SYNTHESIS UNDER THE ACTION OF CONTACT SUBSTANCES (30)



conceived as a reult of reactions of free methylene radicals into which the hexamethylene is decomposed in the catalytic reaction. Some of these radicals methylate the newly formed benzene to methyl- and dimethylbenzene, while the molecules of cyclohexane not yet dehydrogenated are methylated by the same radicals to methyl- and dimethylcyclohexane.

When gaseous hydrocarbons are subjected to a very high temperature (900-950° C.) in a strongly rarefied atmosphere, free methyl and ethyl radicals are known to be formed; similar radicals, in the case under discussion methylene, can apparently be formed also at lower temperatures under the action of the catalyst.

There seems to be no basis for an assumption that in all catalytic processes formation of intermediate temporary compounds from the reacting substances and the contact bodies takes place. The author agrees with Mendeleev that a mere contact is sufficient to bring about a dynamic strain in the molecules which results in some cases in rupture of the ring, its isomerization or in creation of a new ring from open chains changing the energy level of the valence bonds, while in other cases the ring of cyclohexane is completely dehydrogenated to benzene.

All above mentioned phenomena that change the chemical nature of hydrocarbons depend upon simple contact with metal catalysts prepared in a definite way. With regard to decomposition of cyclohexane into hydrogen and benzene it may be regarded as a dissociation at a considerably lower temperature (beginning with 150°) under the action of the contact substances.[31] Out of contact with these metals the stability of the cyclohexane is so high that even at much higher temperatures it does not undergo dehydrogenation.

These studies were started because of their theoretical significance, but the derived conclusions were found to be also of practical use. The contact aromatization of gasoline and ligroin fractions of oil constitutes a method of preparation of large amounts of aromatics. Conversion of cyclopentanes into isoparaffins is also of practical importance.

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Tests on Defense Gasoline Containers

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IN the shipment and storage of petroleum products, present world conditions and our national defense program bring up some considerations not ordinarily encountered. Light petroleums, and especially high-octane aviation gasoline, must be shipped to outlying points such as our island bases and must be safeguarded from destruction by possible enemy air or sea attack.

Handling in drums seems generally indicated. The usual heavy returnable container cannot be economical if it is not re-used, and return shipment of vast numbers of empties can only further tax an already busy transportation system. Furthermore, the substitution of the lighter pressed-steel non-returnable drum should impose less burden in the form of immediate steel demand and at the same time permit the manufacture of greater total container capacity within a given time.

Open storage of gasoline drums under tropical conditions must resist evaporative losses and consequent change in octane rating, springing of seams due to temperature-pressure changes, and contamination from heavy rains. If, as has been proposed, full drums are sunk beneath the ocean surface as a protective measure, they must further resist the intrusion of sea water under considerable pressure.

To the Chemical Engineering Division of the Armour Research Foundation in Chicago fell the task of determining by preliminary study the suitability of 18-gauge pressed-steel drums equipped with the standard type of pressed-in closure. This closure, a sawed section of which is shown in Figure 1, consists of a threaded flange pressed into a stamped opening in the end or side of the sheet-steel drum. The seal between the two metal surfaces is effected by a natural or synthetic rubber gasket. A threaded plug, also fitted with a gasket, is screwed into the threaded flange to complete the closure. As a further safeguard, a tamper-proof metal seal equipped with a cork ring is formed into place over the entire closure in a single operation by means of a special crimping tool.

The actual testing procedure resolved itself into establishing on a laboratory scale the conditions under which the closures would be used in practice. These conditions included submergence in salt water to a depth of 300 feet, and exposure to exceptionally severe weather conditions. The first test, conducted in the laboratory, will be discussed first.

The closures to be tested were pressed into circular sections of sheet-steel drum stock. The assemblies were placed on the ends of the circular pressure chamber and pulled up against gaskets by means of tie bolts and pressure rings. The closures were so placed that the side ordinarily on the outside of a drum faced the inside of the pressure chamber.

The pressure chamber was filled with Atlantic ocean water and connected to a vertical reservoir also filled completely with sea water. A rubber diaphragm placed at the water-air interface served to prevent solution of air in the water. Air pressure of 140 pounds per square inch was placed on the system. Thus each closure was subjected to sea water contact at this pressure on the side corresponding to the exterior of the drum, with atmospheric pressure on the opposite surface.

Closures tested included unplated, cadmium-plated and zinc-plated flanges with both die cast and steel plugs. The flanges and plugs were arranged in all possible combinations. The sea water pressure was maintained on each combination continuously for 168 hours. Frequent examinations for leaks were made, and at the conclusion of the test both flanges and plugs were examined for corrosion. The results are given in Table 1.

Within a short time after completion of the above tests a report reached this laboratory that a boat load of 52,000 drums of oil sank in the harbor of Texas City. The drums, equipped with the type of closure tested, were completely submerged, thus furnishing a further opportunity for checking the Armour Research Foundation test. Numerous samples removed from the raised drums by the adjuster for the underwriters failed to show any salt water contamination whatsoever.

The second series of tests made to determine the effect of abnormally severe weather conditions upon the storage of 100-octane aviation gasoline in 18-gauge standard steel drums equipped with the above type of closure presented several difficulties. Since the handling of a large volume of highly inflammable gasoline with its natural fire and explosion hazard was necessary, preliminary tests were made to determine the pressure limits within which a standard steel drum could be handled safely. For this purpose one drum was selected at random out of 5 new identical drums of 55-gallon marked capacity, manufactured from 18-gauge sheet steel, and equipped with both 2-inch and ¾-inch size closures described above.

This drum was connected with a hydraulic line and a pressure gauge. The line was attached by screwing a standard pipe into the ¾-inch flange, while the 2-inch closure was tightened down and sealed in the usual manner. The drum was filled with water, then additional water was slowly forced into the drum by means of a hydraulic pressure

TABLE 1
Effect of Sea Water Pressure on Drum Closures

Closure		168 hrs at Sea Water Pressure 140 lbs/in²	
Flange	Plug	Closure Leakage	Significant Corrosion
Unplated	Die cast	None	None
Unplated	Steel	None	None
Cadmium plated	Die cast	None	None
Cadmium plated	Steel	None	None
Zinc plated	Die cast	None	None
Zinc plated	Steel	None	None

pump. Pressure readings were taken, and the drum and closures carefully examined for leaks over a 4-hour period of gradual pressure increase.

The first small leak in the peripheral seam of the drum developed at a pressure of 37 pounds per square inch. No leaks developed in the closures.

As another preliminary test two 2-inch closures assembled in circular test sections of drum stock were attached to the ends of a small steel cylinder in a normal position. The plugs were equipped with thiokol and neoprene gaskets, respectively. The assembly was immersed in a water bath whose temperature was maintained at approximately 160° F. Air was piped into the steel cylinder at a pressure always in excess of 100 pounds per square inch with a maximum of 160 pounds per square inch. Thus the closures and gaskets were subjected to a condition corresponding to a high pressure within a drum at an elevated temperature. This test, continued for a period of 48 hours, produced no leaks.

The above preliminary tests indicated that no particular hazard existed in conducting the major test if proper precautions were employed. However, due to fire and insurance regulations it was necessary to carry out the tests of subjecting full drums of aviation gasoline to relatively high temperatures in a space well removed from buildings. For this purpose two small sheds were erected on the grounds of the Armour Research Foundation. One of these was built with double cellulose walls filled with fiberglass insulation. Roof and floor were similarly insulated because of the cold weather prevailing. The shed was equipped with a door, window and steam radiators. A small fan connected to a low voltage motor outside the shed by a shaft extending through the wall served to circulate the air. This insulated shed was used for storing the filled drums at high temperatures. The second shed, simply constructed, and 40 feet distant from the first, housed a small steam boiler to supply the radiators in the insulated building.

Four 55-gallon drums, filled to the standard mark with 100-octane aviation gasoline, were sealed with the closures to be tested, using thiokol plug gaskets in half of the closures and neoprene plug gaskets in the remainder. To one of the drums was attached a pressure gauge and a remote-operation thermometer, for pressure and temperature observations within the drums. A second thermometer gave the temperature of the shed. All instruments were readable from the outside of the shed, thus making it unnecessary to open the door during the test.

With all arrangements completed, and with the full drums of gasoline inside the shed, the temperature within the structure was raised to 150° F., and maintained there until 6 p.m., when the temperature was lowered to 70° F. It was maintained at this level under constant supervision until 8 a.m. at which time the daylight shift again raised the temperature to 150° F. At 5 p.m. of the fourth day the door of the shed was opened and water poured over the drums to simulate the effects of a heavy rainstorm. Enough water remained on top of each drum to completely cover all closures. The drums were left in this condition at an approximate air temperature of 35° F. for a period of 16 hours, at the end of which the excess water was removed and the drums opened for inspection of the closures.

At no time during these drum-storage tests did the gasoline temperature rise above 97° F. Pressures within the drums were never higher than 13 pounds per square inch. It appears that the heat gained during the day was adequately dissipated during the night. This, of course, is of the greatest importance if gasoline storage in the above manner is adopted, since the rupture pressure of 37 pounds per square inch for the drums will not be reached. The plug gaskets showed no injury beyond the expected slight increase in diameter in some cases. The gasoline was examined for the presence of water contamination, which was found to be absent.

The general conclusions which can be drawn from the results of the above tests are:

1. The closure of the type tested will effectively withstand sea-water pressure of 140 pounds per square inch without leakage or visible corrosion within the test period.

2. No evaporation losses and contamination by water are incurred if gasoline is stored in 18-gauge steel drums equipped with closures of above type, during storage under climatic conditions similar to those artificially produced during the four-day test period.

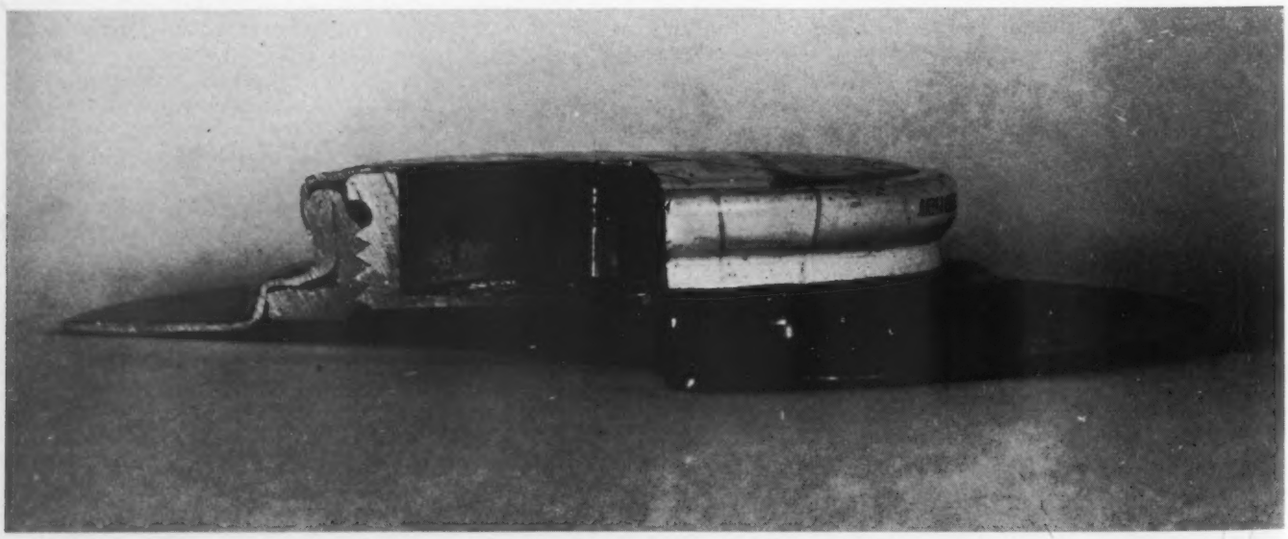


FIGURE 1

Sawed section of closure for pressed-steel drum to hold aviation gasoline

High Chromium Alloys in the Refinery

[Continued from page 72]

heating. All are very ductile at temperatures in excess of 400° F. to 500° F. As one of the most important reasons behind the application of high-chromium steels involves their use at high temperatures, welded structures are perfectly suited under these operating conditions. There is, however, one exception to this general rule. If welded structures are held in the range 750° F. to 1100° F. for long periods of time, they will be found to be brittle when cold. This effect is shown for a 17-percent-chromium steel in Figure 6. By heating to 1400° F. to 1500° F. and cooling rapidly the original ductility may be restored.

As the chromium content increases, the weld metal becomes more and more brittle and less and less susceptible to annealing. At a black heat of about 900° F. the 27-percent-chromium steels may be welded with ease. At this high a temperature these steels are fairly ductile. But they become brittle when cooled. Therefore they must be reheated to a red heat after welding and rapidly cooled. Just as with the 17-percent-chromium steels the 27-percent-chromium types are intended for use at elevated temperatures. In this environment they possess sufficient ductility.

As one of the large uses of the 12-percent-chromium type is in the lining of pressure vessels and pressure vessel attachments, emphasis must be made one this phase of welding. Considering the light gauges commonly associated with such work and the low carbon content of the weld metal as well as the plate material, no difficulty is experienced with cracking. Neither is heat treatment of the usual type 410 found in this application practiced. By avoiding excessive puddling of the weld metal by making all plug welds in the two steps illustrated in Figure 7, cracks in the welds are avoided.

Mention was made earlier of the desirability of maintaining chromium at a minimum content of 11 percent. When alloy liner is joined to mild-steel shell, dilution is bound to occur. Many fabricators resort to an 18-8 filler metal to avoid harmful dilution. But the vast majority of alert fabricators are turning to 25-20

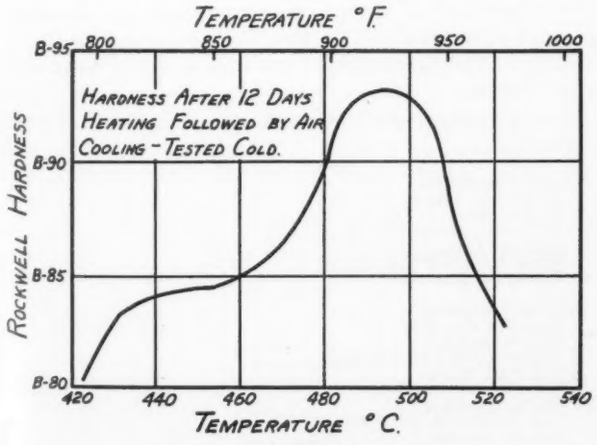


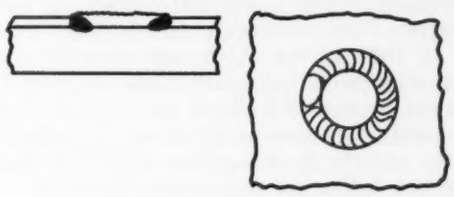
FIGURE 6

Embrittlement of 17 percent Cr steel

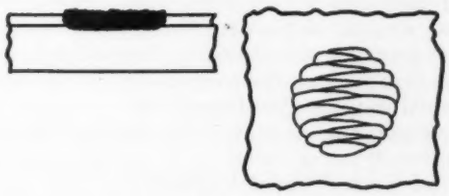
where an ample reserve of chromium is to be had. Absolute freedom from corrosion worries goes hand in hand with the completion of perfect welds exhibiting the highest type of physical properties. When the overall cost of this type of work is considered, the slight increase in price per pound for filler metal is more than justified.

The last alloys in this discussion are the austenitic types. In contradistinction to those types that do not contain nickel the chromium-nickel alloys are easy to weld. Almost always, unless they are being joined to a dissimilar material, the austenitic alloys are welded with weld metal of like composition.

Certain precautions must be taken in this welding. Some of the same considerations apply to the straight-chromium field. For instance, it is necessary to avoid carburization, or increase in carbon,



PLUG WELDING - FIRST STEP



PLUG WELDING - SECOND STEP

FIGURE 7

A two-step method of plug welding

because this increase will affect the corrosion resistance adversely. Then, too, slag and foreign metal must be guarded against. Either of these conditions might increase corrosive activity many times. And, especially in repair work, the surface to be welded must be cleaned thoroughly. All evidences of corrosion, all oil, grease or coke must be completely removed until clean sound metal is revealed. Either sand blasting or chipping is recommended as a preparatory treatment. In repairing cracks the defective portion must be removed in its entirety before repairs are begun. Attention to these details is important if the best results are to be obtained.

Sometimes a combination of cleaning and peening will prove beneficial in the making of multi-pass welds. Each time the arc is broken that crater should be cleaned before going on with the weld. An extra precaution exists in the use of stainless steel wire brushes. The ordinary low-carbon-steel brushes might contaminate the stainless surface, thereby encouraging pit corrosion.

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Evaluation of Diesel Fuels In Full-Scale Engines

Report of Cooperative Fuel Research Committee

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Sinclair Refining Company

THE CFR Full-Scale Engine Group was organized by engine men representing the major classifications of automotive-type diesel engines. This original group, with the cooperation of the representatives of the petroleum industry, the government agencies, and colleges, has carried on an extensive series of tests on commercial diesel engines.

The purpose of the investigation was to determine the influence of fuel properties such as cetane number, viscosity, volatility, and gravity on the engine performance.

Starting and engine smoothness are dependent upon the ignition quality of the fuel.

Smoke and engine deposits vary with the volatility and viscosity.

Exhaust odor varies with ignition quality and cetane number.

Power output and fuel consumption vary with the heat value of the fuel.

At a given pump setting, viscosity may have an independent effect on the power output because of plunger leakage.

The limited number of fuels used in this series of tests makes it impossible to isolate all fuel properties and their effect on fuel performance, but the results obtained will guide future investigations.

This paper was Presented to Division of Refining, before Eleventh Mid-Year Meeting of the American Petroleum Institute, at the Mayo Hotel, Tulsa, Oklahoma, May 22, 1941.

THE Automotive Diesel-Fuels Division of the CFR Committee was organized in September, 1937, at the request of the Volunteer Group for Compression-Ignition Fuel Research, and has continued the activity of that group. Although some fuel testing had been done with full-scale diesel engines † in the development of the CFR diesel test method, it was felt that a separate group was necessary in order properly to carry out the investigation of fuel properties as they affected full-scale-engine performance.

The Full-Scale Engine Group was organized for the purpose of clarifying the issue of automotive diesel-fuel specifications by determining those properties of analyses which influenced engine performance and engine deposits. The group was formed with the primary membership consisting of engine men who represented the four essential classifications of automotive-type diesel engines.

At least two engine men were selected to represent each engine type, as well as a representative from the United States Naval Experiment Station at Annapolis. These engine men met at Peoria, Illinois, July 26, 1939, and agreed to conduct prescribed tests on multi-cylinder diesel engines of their own manufacture, selected with characteristics within the following limits: bore, 3½ inches to 4½ inches; number of cylinders, 4 to 6; speed, 1500 to 2000 rpm. The factors selected as essential to the investigation of fuels were: 1, cetane; 2, volatility; 3, viscosity; and, 4, gravity—and their effect on: 1, starting; 2, smoothness; 3, smoke; 4, power output; 5, fuel consumption; 6, smell; and, 7, engine deposits.

The fuels required for this investigation were to be straight-run products to cover a range of cetane number, volatility, viscosity, and gravity. Four fuels subsequently were specified, and a fuels group was appointed to arrange for the manufacture and distribution of these reference fuels. The laboratory inspection data on those fuels are given in Table 1.

An instrumentation group was selected for the purpose of setting up instrumentation and procedure in order to standardize the methods of test employed by the various laboratories. This group functioned throughout the entire investigation.

A secondary group, consisting of representatives from the petroleum industry who have engines in their laboratories of the types of manufacture as represented by the engine men of the primary group, either single- or multi-cylinder structures, was invited to participate. The petroleum men were to run tests as prescribed for and by the engine men, and to contribute supporting data to the respective representatives of the engines manufactured by the enginemen group.

Representatives from colleges and government agencies were invited to test the reference fuels according to the prescribed tests and to contribute data to the group.

The 16 companies that participated in the full-scale program are:

A. Engine Companies:
1. Caterpillar Tractor Co.
2. General Motors Corp.
3. Fairbanks, Morse and Co.
4. Chrysler Corp.
5. Mack Manufacturing Corp.
6. Waukesha Motor Co.

B. Refining Companies:
1. Shell Oil Co., Inc.
2. The Texas Co.
3. Standard Oil Co. (Indiana).
4. The Pure Oil Co.
5. Standard Oil Development Co.
6. Sinclair Refining Co.
7. The Atlantic Refining Co.
8. Socony-Vacuum Oil Co., Inc.

C. Associated Groups:
1. University of Wisconsin.
2. Pennsylvania State College.

A progress report was presented at the summer meeting of the Society of Automotive Engineers at White Sulphur Springs, W. Va., June 11, 1940, by chairman C. G. A. Rosen. The data used as a basis

† Report of Volunteer Group for Compression-Ignition Fuel Research by C. H. Baxley and T. B. Rendel, *SAE Journal*, Jan., 1938.

TABLE 1
Laboratory and Inspection Data of Test Fuels

Fuel:	A	B	C	D	Blend of 50 Percent B 50 Percent D
Fuel Characteristic	High Cetane Number	Low Volatility	Low Cetane Number	High Volatility	
Ignition Quality:					
A. Diesel index number	61.5	37.6	36.9	55.6	46.0
B. Cetane number	56.1	40.5	33.2	41.3	40.8
Viscosity at 100 °F.:					
A. Kinematic, centistokes	3.24	7.81	3.33	1.54	3.04
B. Saybolt universal, seconds	37	51	37.5	31	36
ASTM Distillation, in °F.:					
A. Initial boiling point	427	468	380	367	379
B. 10-percent point	475	535	445	390	410
C. 50-percent point	527	607	502	413	489
D. 90-percent point	584	672	574	449	650
E. End point	625	729	642	487	704
Gravity, deg. API	37.6	26.6	29.1	40.8	33.4
Flash point (Pensky-Martens), °F.	206	238	168	157	170
Pour point, °F.	0	20	B-10	B-10	—5
Water and sedmient, percent	0	Trace	0	0	Trace
Corrosion:					
A. 3 hours at 130 °F.	Negative	Negative	Negative	Negative	Negative
B. 3 hours at 212 °F.	Negative	Negative	Negative	Negative	....
Total sulfur, percent	0.13	0.60	0.11	0.07	0.36
Carbon residue, (on fuel), percent	0.014	0.023	0.01	0.014	0.027
Carbon residue (10 percent bottoms), percent	0.03	0.21	0.04	0.027	0.139
Ash, percent	0	0	0	0	0
Color:					
A. ASTM	1	5—	1¼—	....	....
B. Saybolt	—10	....	....	+19	....
Heat content:					
A. Btu per gal	137,945	143,347	142,186	135,452	....
B. Btu per lb	19,763	19,164	19,345	19,571	....
*Modified ASTM gum, mg. per 100 ml	32.0	925.0	66.0	6.0	....
*Hercules gum residue, mg. per 100 grams	16.0	139.5	26.5	10.0	....

* Average of two laboratories.

for that report, along with additional data submitted after that date, were used as a basis for this report.

An analysis group was selected from those members most familiar with the data submitted. The personnel of this group was made up of the five representatives of the diesel-engine manufacturers who submitted reports and five representatives of the oil refiners active in the program. As instructed by the full-scale group at the meeting in Detroit, January 9, 1941, this group held a two-day meeting and: 1, prepared recommendations on the automotive diesel-fuel characteristics as indicated by the full-scale engine research test data and the laboratory and field experience of those present; 2, made a preliminary study of the data available, and formulated a general plan and program for the more detailed analysis. A detailed report of the recommendations on the required diesel-fuel characteristics is given in Appendix "A."

In carrying out the actual work of studying and of evaluating the data, it was necessary to enlarge the original group. The personnel of the group responsible for the formulation of this report was as follows:

W. G. Ainsley, Sinclair Refining Co.
W. F. Aug, Mack Manufacturing Co.
A. J. Blackwood, Standard Oil Development Co.
K. M. Brown, Caterpillar Tractor Co.
W. H. Browne, Caterpillar Tractor Co.
J. M. Campbell, General Motors Corp.
C. E. Cummings, The Texas Co.
W. E. Drinkard, Chrysler Corp.
J. O. Eisinger, Standard Oil Co. (Indiana)
A. H. Fox, Standard Oil Co. (Indiana)
H. M. Gadebusch, General Motors Diesel Division.
L. W. Griffith, Shell Oil Co., Inc.
L. E. Hebl, Shell Oil Co., Inc.
S. L. Henry, Fairbanks, Morse and Co.
C. G. A. Rosen, Caterpillar Tractor Co.
G. C. Wilson, University of Wisconsin.
H. D. Young, Sinclair Refining Co.
G. W. Zabel, Fairbanks, Morse and Co.

Reports were received on engine testing as conducted in 10 laboratories employing 15 individual engines of 7 different makes. The data on the engines used in these tests are given in Table 2.

Inasmuch as data available on this report were gathered from several engines by different contributing laboratories, the problem of correlation was a difficult one. The reported results had to be brought to a common basis before any fuel-property influence could be analyzed.

The fact that the fuel properties are interrelated, and that only four basic reference fuels and cross-blends were investigated, made the interpretation of the results in terms of fuel properties a task which in some cases was impossible to solve at this time. To facilitate the correlation of engine-test data with fuel properties, all specific values were converted into percentages relative to one of the fuels.

Engine Deposits

The engine-combustion-chamber-deposit test method was intended to be used as a means of comparing fuels by determining the combustion-chamber-deposit-forming tendencies under operating conditions simulating an elevation of 5000 feet. The engine was operated at no load and at rated speed continuously for 50 hours on the fuel under test. The intake air was throttled to 5 inches mercury depression during the entire test (this is the equivalent of operation at an altitude of approximately 5000 feet). Water and oil temperatures were maintained at normal levels.

At the conclusion of the test, photograph records were made of fuel valves, exhaust and intake valves, cylinder walls, and underside of cylinder head and valve ports. The deposits were scraped carefully from fuel injection valves, exhaust valves and exhaust ports, air-inlet passages, cylinder walls and pistons

TABLE 2
Reports on Engine Testing—15 Engines, 7 Makes

ENGINE	Company Reporting	Bore (Ins.)	Stroke (Ins.)	No of Cylinders	Compression Pressure (PSI)	Compression Ratio	Combustion System	Injection System	Displacement (Cubic Inches) Total	Displacement (Cubic Inches) Per Cylinder	Rated Brake Mean Effective Pressure (PSI)	Speed Range (RPM)
General Motors Corporation 3-71	Texas	4¼	5	3	500	19/1	Open	Own	213	71	57	500-2,000
General Motors Corporation 3-71	Atlantic	4¼	5	3	500	19/1	Open	Own	213	71	57	500-2,000
General Motors Corporation 3-71	StandardOilDevelopment	4¼	5	3	500	19/1	Open	Own	213	71	57	500-2,000
General Motors Corporation 1-71	Shell	4¼	5	1	500	19/1	Open	Own	71	71	57	500-2,000
Hercules DKXB	StandardOilDevelopment	3½	4½	6	....	....	....	....	....	....	....	....
Fairbanks, Morse and Company	University of Wisconsin	4¼	6	1	580	16.8/1	Precombustion chamber	Bosch	85	85	77	500-1,200
Fairbanks, Morse and Company	Shell	4¼	6	1	580	16.8/1	Precombustion chamber	Bosch	85	85	77	500-1,200
Fairbanks, Morse and Company	Fairbanks-Morse	4¼	6	4	580	16.8/1	Precombustion chamber	Bosch	340	85	77	500-1,200
CFR	Standard Oil (Indiana)	3¼	4½	1	....	Variable	Precombustion chamber	Bosch	37.5	37.5	..	600-2,000
Dodge T106	Chrysler	3¾	5	6	450	14.7/1	Turbulence chamber	.....	331	55	88	500-2,600
Dodge	StandardOilDevelopment	..	..	..	.....	.....	.....	.....	...	...	..	.....
Dodge TKD	Atlantic	3¾	5	6	.....	14.5/1	Lanova	.....	331	55	..	.....
Mack	Mack	4	5⅜	6	....	14.6/1	Lanova	Bosch	405.3	67.5	100	.....
Caterpillar E48	Caterpillar	3¾	5	4	745	18.5/1	Precombustion chamber	Own	221	55.2	55.2	600-1,650
Caterpillar 1A138	Caterpillar	4¼	5½	1	695	17/1	Precombustion chamber	Own	78	78	80	600-1,500

above top rings, and cylinder heads, and weighed separately to the nearest 0.01 gram.

Engine deposition, as herein discussed, concerns only that portion of material commonly designated as combustion-chamber deposits. The influence of fuel characteristics upon this specific condition involves a detailed study of deposits occurring in various typical engines under conditions set forth in the method of test.

A tabulation of engine-deposit data is given in Table 3.

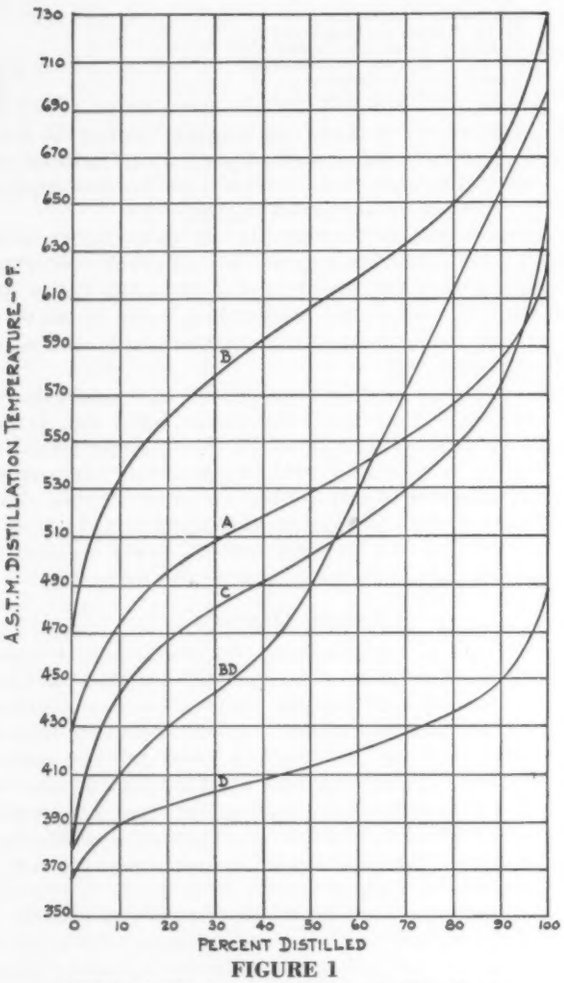


FIGURE 1
ASTM Distillation—Full Scale on Test Fuels.

Fuels "A" and "C" possess slight differences in their volatility characteristics, but have wide differences in ignition qualities (33.2 to 56.1 cetane number). Figure 2 is a curve indicating that cetane number is related to combustion-chamber deposits, although the distribution of points (Figure 2) representing tests on fuels of approximately 40 cetane number suggests that there may be other factors which have a greater effect.

Figures 3 and 4 show relative deposits plotted against the 90-percent point and the end point (ASTM distillation), respectively, with curves drawn through the averages of relative deposits. These curves indicate that volatility has an effect on combustion-chamber deposits, which effect becomes more pronounced in the high boiling range.

Figures 5 and 6 show relative deposits plotted against viscosity (Saybolt Universal seconds) and API gravity, respectively. These curves indicate that these fuel characteristics have an effect on engine deposits. Again it should be noted that the spread of average points, when more than one fuel was tested of the same viscosity, shows that other factors probably have an effect.

Curves in Figures 7 and 8 indicate that carbon residue on 10 percent bottoms and the Hercules residue test show fuel properties which have an effect upon combustion-chamber deposits for the types of fuels investigated. The co-plots of the results of the residue of the 10 percent bottoms against Hercules

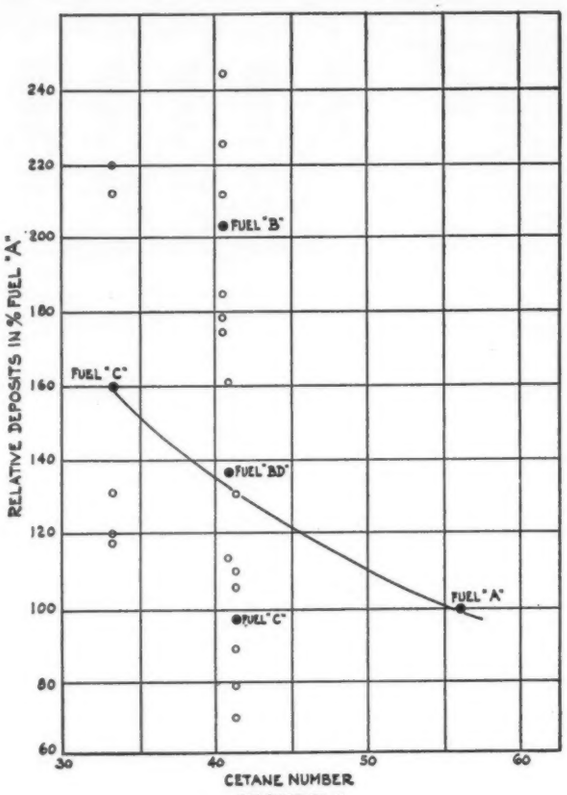


FIGURE 2
Relative Deposits Vs. Cetane Number.

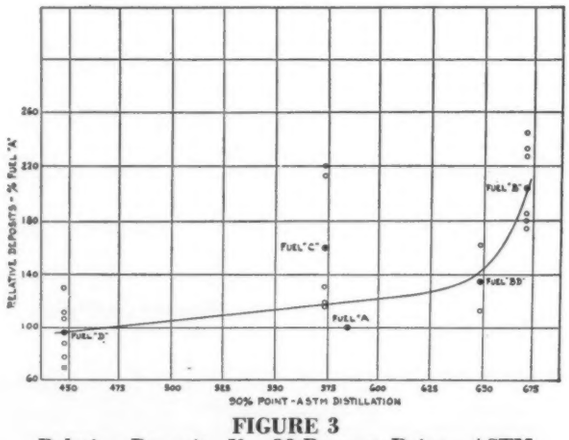


FIGURE 3
Relative Deposits Vs. 90-Percent Point—ASTM Distillation.

residue test and the modified ASTM gum test, as shown in Figures 9 and 10, show linear relationship which indicates that modified ASTM gum tests, carbon residue on 10 percent bottoms, and the Hercules residue test appear to measure the same fuel property. As the fuels employed in this work contained little cracked stock, it is desirable to confirm these findings by further investigations.

Engine Smoothness

The pressure rise per degree of crank angle was employed as an indication of engine-combustion

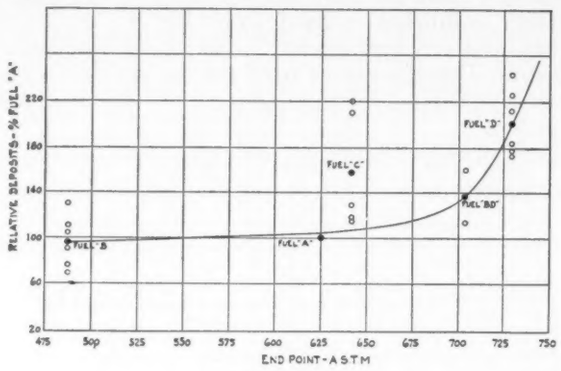


FIGURE 4
Relative Deposits Vs. End Point.

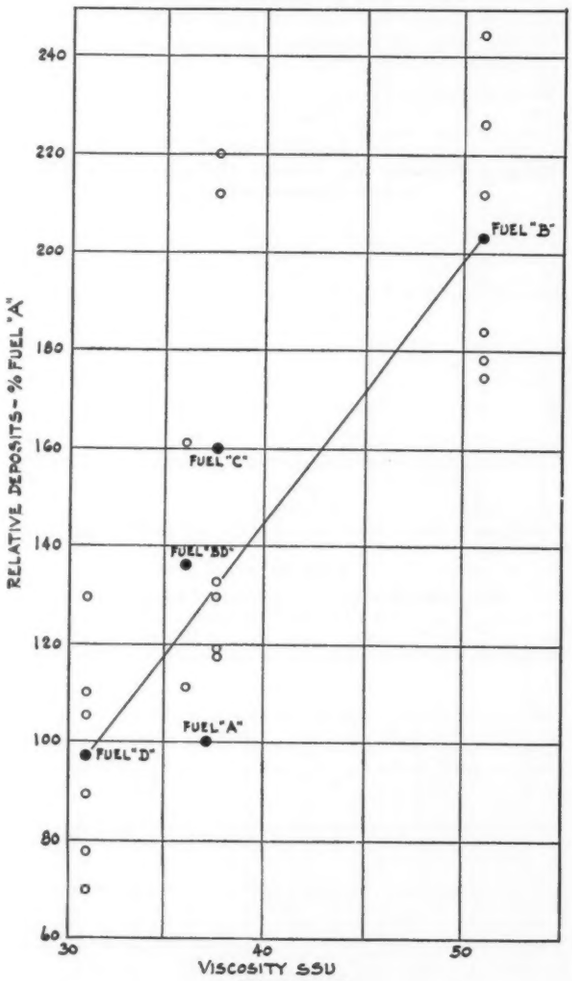


FIGURE 5
Relative Deposits Vs. Saybolt Universal Viscosity, in Seconds.

smoothness. In most cases data were obtainable from combustion oscillograms. One laboratory reported results based on an aural method, and its relative ratings agreed quite well with those obtained from oscillograms.

Five companies submitted data on five engines, representing four different makes. The data showing the effect of cetane number on relative engine roughness are given in Table 4, and a plot of these data against cetane number is shown in Figure 11.

TABLE 3
Engine-Deposit Data

CODE	TOTAL WEIGHT IN GRAMS A	B	C	D	½ B Plus ½ C	½ A Plus ½ C	¼ A Plus ¾ C
1.....	8.06	14.29	9.57	8.45	9.10	....	....
2.....	94.8	173.7	111.3	73.8	....	....	....
5.....	7.71	18.81	10.02	10.0	....	....	....
6.....	27.6	58.6	60.9	24.6	44.5	....	....
7.....	42.8*	75.2	....	30.0	....	53.0	20.2
13.....	11.39	25.70	24.07	12.56	....	....	....

* At 2,500 rpm for 24 hours only.

CODE	PERCENT OF FUEL "A" A	B	C	D	½ B Plus ½ D	½ A Plus ½ D	¼ A Plus ¾ C
1.....	100	178	119	105	113	....	....
3.....	100	184	118	78	....	....	....
5.....	100	244	130	130	....	....	....
6.....	100	212	220	89	161	....	....
7.....	100	175	....	70	....	124	47
13.....	100	226	212	110	....	....	....
Average...	100	203	160	97	137	124	47

It is needless to say that fuel "A" produced different rates of pressure rise in the different engines (see Table 4), which ranged from 21.0 to 49.0 psi per degree of crank angle. Inasmuch as roughness in one engine apparently was not affected greatly by cetane number in these tests, the data on this engine have been considered separately—and a dotted line has been drawn through those points in Figure 11. The results of the other four engines have been averaged, and these are indicated by the "solid-square" symbols. It is apparent that cetane number of a diesel fuel over the range investigated (i.e., from 33.2 to 56.1) has a marked effect on engine-combustion roughness.

The ASTM 90-percent point, end point, API gravity, and viscosity (Saybolt Universal seconds), over the ranges studied, show no substantial correlation with engine-combustion roughness.

Starting

The four laboratories used different methods of evaluating the starting characteristics of the fuels. One laboratory determined the starting time for the

TABLE 4
Effect of Cetane Number on Relative Engine Roughness

ENGINE No.	POUNDS PER SQUARE INCH PER DEGREE OF CRANK ANGLE Fuel A	Fuel B	Fuel C	Fuel D	Blend of 50 Percent B 50 Percent D
1.....	21.0	26.5	22.5	24.0	23.0
4.....	35.0	75.0	70.0	60.0	.....
6.....	49.0	90.0	144.0	77.0	99.0
	AURAL RATINGS				
9.....	3.5	6.5	7.5	4.5	.....
11.....	4.0	7.5	8.5	8.0	.....

Engine No.	RELATIVE ROUGHNESS (FUEL A =100 PERCENT) Fuel A	Fuel B	Fuel C	Fuel D	Blend of 50 Percent B 50 Percent D
1.....	100	126	107	114	110
4.....	100	214	200	171	.....
6.....	100	184	294	157	202
	AURAL RATINGS				
9.....	100	186	214	128	.....
11.....	100	188	213	200	.....

various fuels at room temperatures and jacket-water temperatures of about 70° F. The electric dynamometer was used as a cranking medium at 350 rpm.

One laboratory artificially cooled the engine by using, for the intake, cold air provided by the exhaust from an air motor and by circulating a coolant through the jacket. Air temperature was maintained at approximately 15° F., and jacket temperature was maintained at approximately 17° F. The cranking time was determined for each fuel with the use of a starter with a cranking speed of approximately 170 rpm.

One laboratory artificially cooled the engine by placing it in a cold room and allowing sufficient time

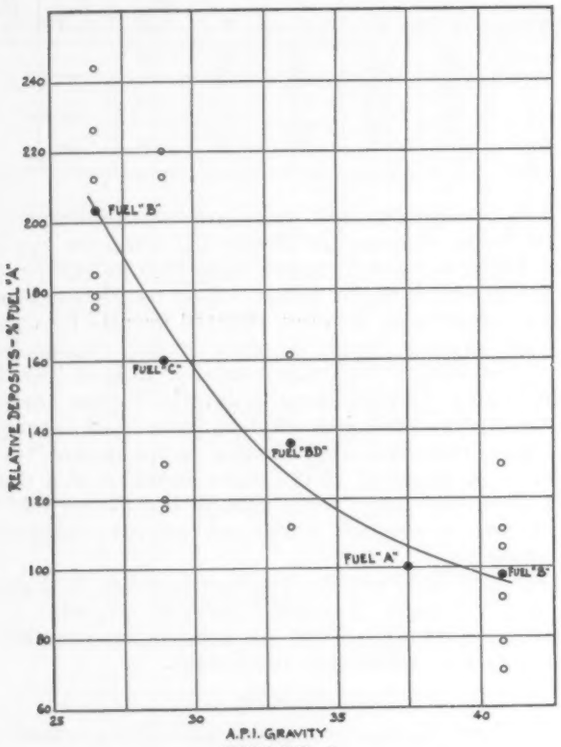


FIGURE 6
Relative Deposits Vs. API Gravity.

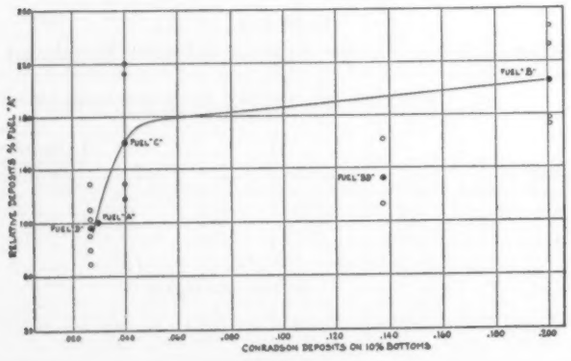


FIGURE 7
Relative Deposits Vs. 10 Percent Bottoms.

between starting attempts for the engine and surroundings to reach a temperature of 35° F. the engine was cranked at constant cranking speed by means of a starter and batteries. Cranking speed was constant at 260 rpm. The time for a start was determined for the various fuels.

The other laboratory reported the minimum cranking speed in revolutions per minute necessary to start the engine at a jacket temperature of 80° F. and air temperature of 86° F. for the various fuels. The starting data are given in Table 5.

For the three laboratories reporting in seconds, the starting conditions varied from 15° F. air, 17° F. jacket, and 168 rpm, to 70° F. air, 74° F. jacket, and 350 rpm. The conditions used for the results in minimum revolutions per minute were 86° F. air and 80° F. jacket.

The curve in Figure 12 indicates that, for the ma-

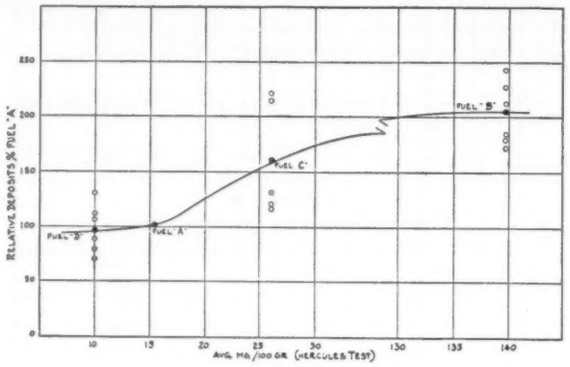


FIGURE 8
Relative Deposits Vs. Average Milligrams Per 100 Grams (Hercules Test).

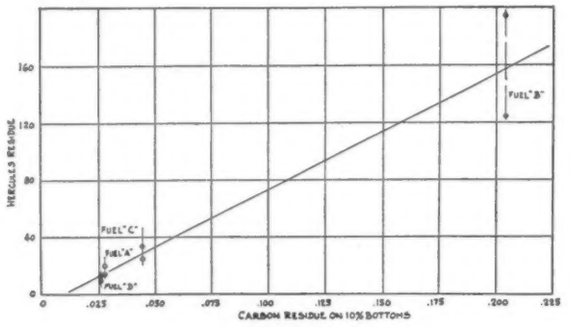


FIGURE 9
Hercules Residue Vs. Carbon Residue on 10 Percent Bottoms.

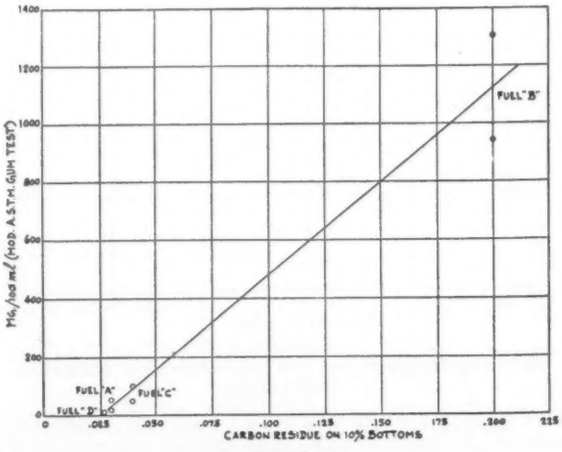


FIGURE 10
Milligrams Per 100 Ml (Modified ASTM Gum Test) Vs. Carbon Residue.

jority of the engines reported, the cetane number affects the ease of starting. The higher the cetane number, the easier.

The other fuel properties failed to show any independent influences.

Smoke

The smoke data presented here were determined in nine laboratories with nine different smoke meters. These were of two general types—full-flow and sampling. The former was used by two laboratories, and the latter was used by the other seven. The effective lengths of the meters varied approximately from 8½ inches to 28½ inches. The results were reported by the laboratories on these different bases—percent smoke, microamperes decrease, and microamperes. In order to correlate these results, it was thought desirable to convert the readings to a common standard. The method was that outlined by K. M. Brown in the paper, "Requirements of a Smoke Meter," presented at the annual meeting of the Society of Automotive Engineers in Detroit, January 9, 1941. The scale used in this method is specific smoke density or density of a column of the smoke 100 meters long. The values as reported and the values calculated to a common standard are given in Table 6.

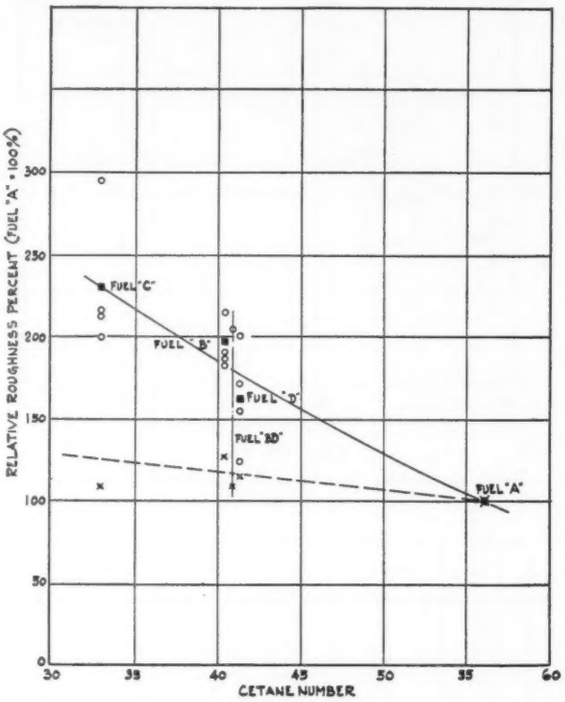


FIGURE 11
Relative Engine Roughness Vs. Cetane Number.

TABLE 5
Starting Data

Code	A	B	C	D	½ B Plus ½ D	
2...	70 rpm	56 rpm	76 rpm	85 rpm	76 rpm	86 °F. air 80 °F. water
3...	38.3sec.	72.6 sec.	138 sec.	80 sec.	.....	15 °F. air 17 °F. jacket 168 rpm
6...	17 sec.	31 sec.	55 sec.	42 sec.	22 sec.	35 °F. air 35 °F. water 260 rpm
9...	31 sec.	73.5 sec.	618 sec.	58.7 sec.	.....	70 °F. room 74 °F. jacket 350 rpm

	PERCENT OF FUEL A					
Code	A	B	C	D	½ B Plus ½ D	
2...	100	80	109	121	108	86 °F. air 80 °F. water
3...	100	190	360	209	.....	15 °F. air 17 °F. jacket 168 rpm
6...	100	182	324	247	129	35 °F. air 35 °F. water 260 rpm
9...	100	237	1,990*	189	.....	70 °F. room 74 °F. jacket 350 rpm
Avg.	100	172	264	192	119	

*Omitted from average.

The curves in Figures 13 and 14 indicate that the smoking tendency of an engine is related to the volatility of the fuel. The limited number of fuels investigated makes it difficult to say whether the break in the curves at 650° F. at the 90-percent point and 700° F. at the end point is a true indication of critical volatility points as far as exhaust smoke is concerned.

The plot of relative smoke vs. cetane number (Figure 15) indicates that smoke decreases with increase in cetane number, although the spread of average values for the several fuels in the neighborhood of 40 cetane number indicates that some other characteristic may have a greater effect than the total effect of cetane within the range covered.

The curve shown in Figure 16 would seem to indicate that the smoking tendency is increased by high viscosities, but it must be remembered that the fuel with the highest viscosity was also the fuel with the lowest volatility. Consequently, it does not necessarily follow that viscosity, within the range of the fuels tested, affects smoking as an independent fuel property.

Curves shown in Figures 17, 18, and 19 indicate an increase in smoking tendency with carbon residue on 10 percent bottoms, Hercules residue, and modified ASTM gum, respectively. Below 0.04 of carbon residue on 10 percent bottoms, the smoke appears to drop off decidedly.

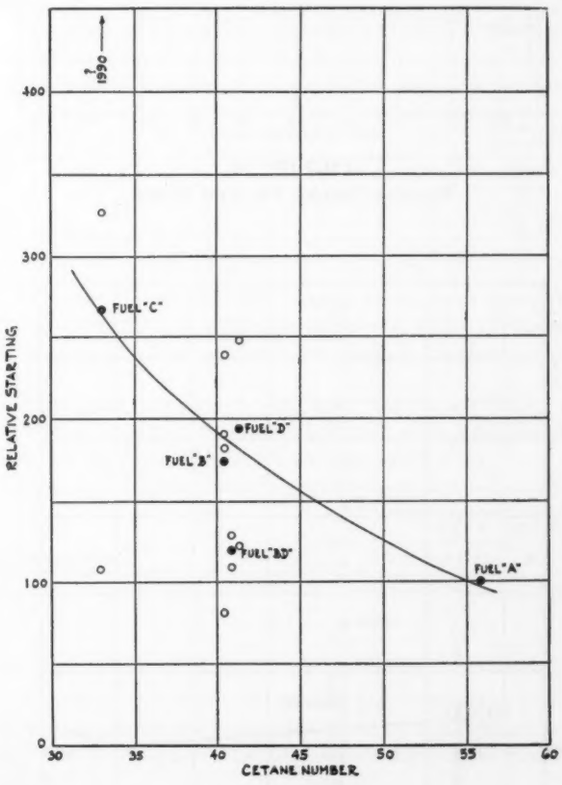


FIGURE 12
Relative Starting Vs. Cetane Number.

From the curve shown in Figure 20 it would appear that there is a correlation between the amount of engine deposits and the smoking tendency of the

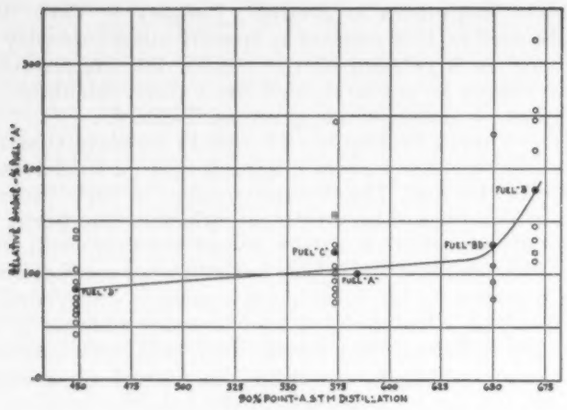


FIGURE 13
Relative Smoke Vs. 90-Percent Point—ASTM Distillation.

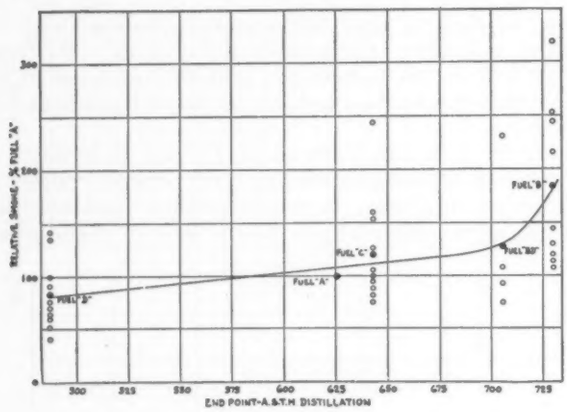


FIGURE 14
Relative Smoke Vs. End Point.

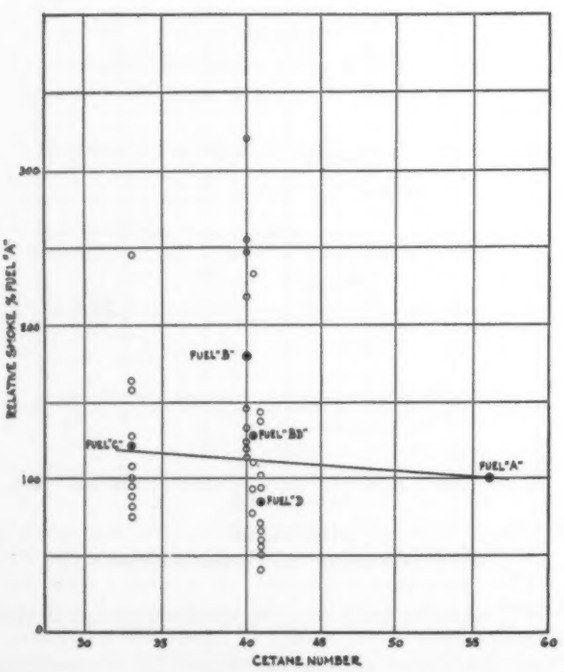


FIGURE 15
Relative Smoke Vs. Cetane Number.

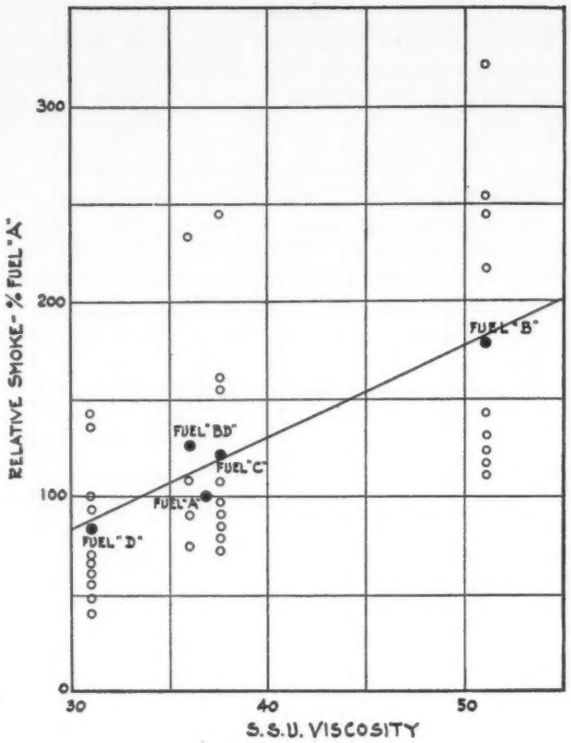


FIGURE 16
Relative Smoke Vs. Saybolt Universal Viscosity, in Seconds.

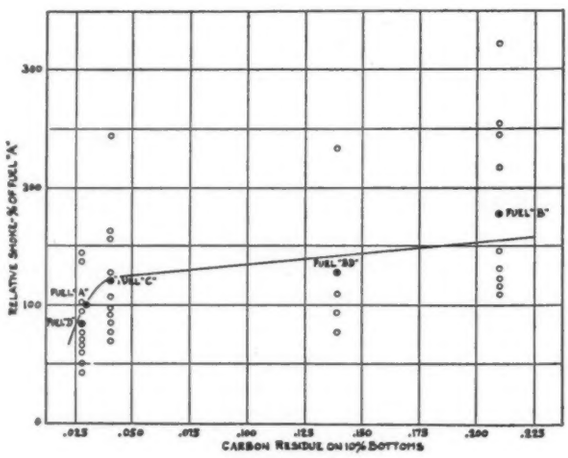


FIGURE 17
Relative Smoke Vs. Carbon Residue.

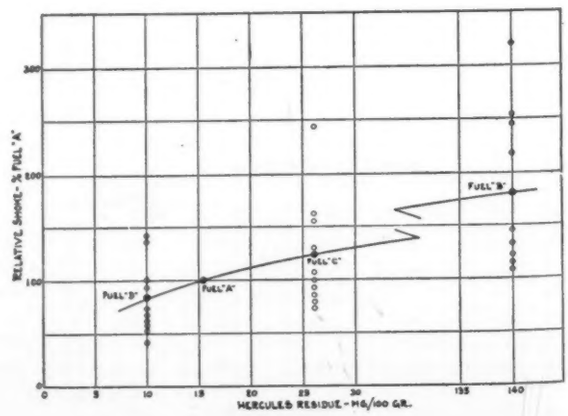


FIGURE 18
Relative Smoke Vs. Hercules Residue.

TABLE 6
Smoke Data

CODE	PERCENT SMOKE AT 85 PERCENT OF MAXIMUM LOAD AT RATED SPEED				
	A	B	C	D	½ B Plus ½ D
1	17	20	21	17	13
3	31.4	66.2	47.6	22.6	33.3
5	58	63	51	70	..
6	28	52	56	37	54
7	10	12	8	6	9
8	8	34	42	7	..
9	36	66	50	33	..
10	14.5	24	20	10	..
11	56	69	51	41	..
12	23	30	21	11.5	..
13	32	40	34	15	..
14	5	4	52	37	..
15	35	75	34	26	..

CODE	SPECIFIC SMOKE DENSITY				
	A	B	C	D	½ B Plus ½ D
1	16	19	20	16	12
3	87	220	139	60	94
5	106	122	87	147	.....
6	41	89	100	57	95
7	53	63	44	36	49
8	22	88	104	19	.....
9	54	132	85	50	.....
11	100	144	87	65	.....
12	58	76	54	31	.....
13	48	63	51	20	.....
14	13	10	134	94	.....
15	53	170	51	37	.....

CODE	RELATIVE SPECIFIC SMOKE DENSITY BASED ON PERCENT OF FUEL A				
	A	B	C	D	½ B Plus ½ D
1	100	119	125	100	75
3	100	253	160	69	108
5	100	115	82	139	.....
6	100	216	244	139	232
7	100	119	83	68	92
8	100	400	473*	86	.....
9	100	245	158	93	.....
11	100	144	87	65	.....
12	100	131	93	53	.....
13	100	131	106	42	.....
14	100	77	1,030*	723*	.....
15	100	320*	96	70	.....
Average	100	177	123	84	127

* Values omitted from average.

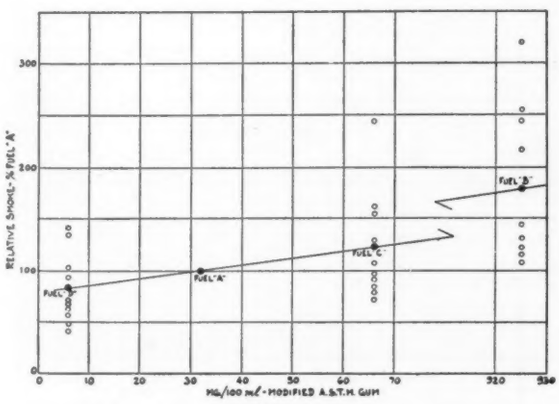


FIGURE 19
Relative Smoke Vs. Modified ASTM Gum.

engine; the more the engine smokes, the greater will be the deposits found.

The following nine laboratories participated in the test work to determine the influence of the four CFR reference fuels on power and consumption:

1. University of Wisconsin.
2. Shell Oil Co., Inc.
3. Fairbanks, Morse and Co.
4. The Texas Co.
5. The Atlantic Refining Co.
6. Standard Oil Development Co.
7. Chrysler Corp.
8. Caterpillar Tractor Co.
9. Mack Manufacturing Co.

Tests were run on single- and 4-cylinder Fairbanks-Morse engines, single- and 3-cylinder General Motors engines, the Dodge diesel, the Caterpillar 4-cylinder engine, and the Mack 6-cylinder diesel engine.

Maximum power: Two of the laboratories determined the influence of the test fuels on maximum power ouput. One type of engine was used exclusively for this work, it being the only one provided with a positive maximum fuel stop. The results were as follows:

Reference Fuel	MAXIMUM POWER OUTPUT (PERCENT)		
	Engine No. 10	Engine No. 13	Average
A	94.0	96.5	95.2
B	100.0	100.0	100.0
C	97.0	97.0	97.0
D	91.6	94.7	93.2

These values show that the maximum obtainable power of this engine drops as much as 6.8 percent over the range of the investigated fuels.

Fuel consumption: All laboratories investigated one change of volumetric fuel consumption occurring when maintaining constant power output with use of the four fuels. The results of these tests, on a percentage basis, are shown in Table 7. This method was selected in preference to presentation of the absolute values, because difference in consumption of the same engine in different laboratories exceeded the maximum variations encountered between all engine types.

Averaging the values given in Table 7, the following summary is obtained:

Reference Fuel	Average Volumetric Fuel Consumption (Percent)
A	103.4
B	100.0
C	101.5
D	105.5
Blend of 50 percent B, 50 percent D	104.7

Of the physical and chemical fuel-oil properties, the thermal value must be expected to be of foremost influence on the amount of power produced in the engine.

The heat values of the four reference fuels were checked by three different laboratories, and the averags are shown in the following tabulation:

Reference Fuel	AVERAGE VOLUMETRIC HEAT VALUE	
	Btu Per Gal.	Percent
A	137,945	96.1
B	143,347	100.0
C	142,186	99.0
D	135,452	94.4

A comparison of the percentage difference of the thermal values with the decrease of maximum power and the increase of the fuel consumption is shown as follows:

Reference Fuel	Thermal Value (Percent)	Maximum Power (Percent)	Volumetric Fuel Consumption (Percent)
A	96.1	95.25	103.4
B	100.0	100.00	100.0
C	99.0	97.00	101.5
D	94.4	93.15	105.5

TABLE 7
Fuel Consumption (Percent)

Reference Fuel	ENGINE NUMBERS										
	No. 4	No. 5	No. 6	No. 10	No. 11	No. 12	No. 13	No. 7	No. 9	No. 1	No. 3
A.....	104.5	102.5	101.5	106.0	105.5	103.0	107.0	103.0	100.0	103.0	101.5
B.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C.....	99.0	99.5	102.0	106.0	98.0	100.0	103.0	102.0	105.0	101.0	100.5
D.....	105.0	103.5	104.0	107.0	106.0	103.5	110.0	104.0	104.5	107.5	106.0
Blend of 50 per-cent B, 50 per cent D..	....	....	103.0	....	....	....	....	108.0	....	103 0	....

These figures reveal clearly that most of the adverse effects of the different fuel properties can be accounted for by the corresponding change of the thermal values.

For practical purposes, the thermal value of a fuel best is expressed by its gravity—which, therefore, can be used to advantage as a criterion for its relative merits with regard to power and consumption.

The curve in Figure 21 shows the plotted results of the consumption test vs. the API gravity of the reference fuels. Due to their basic relation to gravity

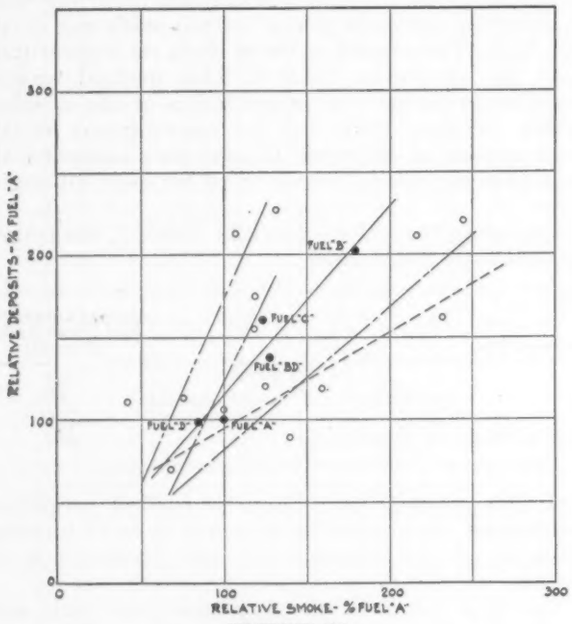


FIGURE 20
Relative Deposits Vs. Relative Smoke.

and heat value, some other properties, such as viscosity and volatility, may reflect the abovementioned results in a corresponding manner.

For average commercial fuels, an increase of the volatility, or a decrease of the viscosity which will accompany an increase of the API gravity, therefore, likewise must be taken as indicative of lowered thermal values—resulting in loss of power and economy.

Odor: Exhaust-odor ratings of the four test fuels, although included in the original program, have been made only by The Texas Company. Inasmuch as these tests were made on only one engine and have not been confirmed by others, the data are not considered in the major conclusions, but are included in Appendix "B," hereinafter, for further consideration.

It is interesting to note, however, that this laboratory reports that, under the specific conditions used, exhaust-odor objectionability is principally a function of fuel-ignition quality (Figure 22), decreasing as cetane value increases. It is indicated also that odor is independent of volatility. The recommendation is made that other laboratories continue this phase of the investigation.

Summary

In summarizing the data from these full-scale diesel-engine tests it is realized that many of the fuel

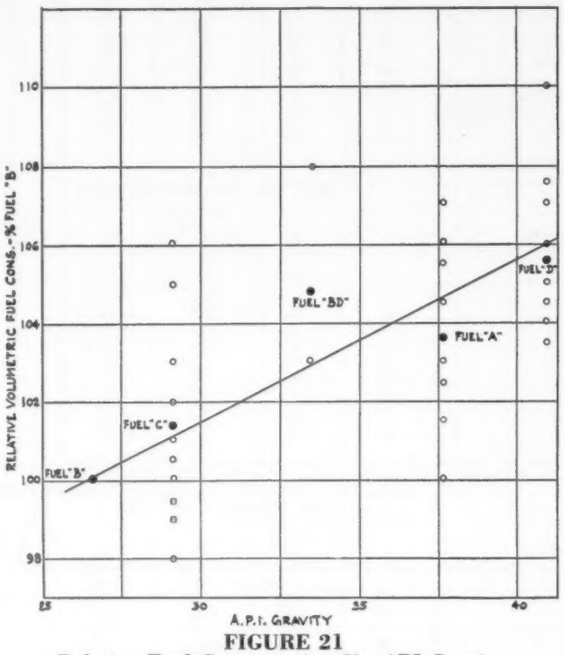


FIGURE 21
Relative Fuel Consumption Vs. API Gravity.

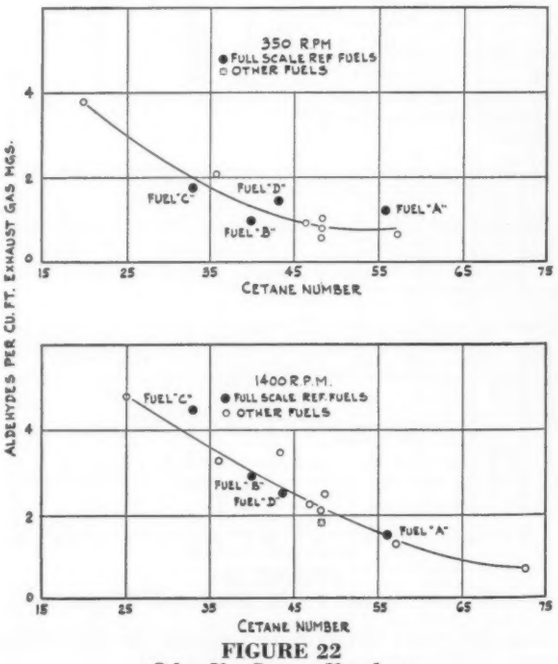


FIGURE 22
Odor Vs. Cetane Number.

characteristics are related; and, although engine performance varies with the test values on the fuels used, it may or may not be a direct relation.

A summary of engine effects as related to the fuel properties is given in Table 8. From this table, which is based on test results obtained on the selected reference fuels, the following conclusions may be drawn:

1. The ignition quality of the fuel (cetane number, ASTM) affects

EUGENE (JACK) PHILLIPS, 1117 Cleckler South, Fort Worth, Texas, winner of first prize of $5,000 in the Revere Award for the idea doing most to help speed America's industrial defense program. Tall and lanky, Phillips is 33 years old and employed as senior radio electrician with the C. A. A. central depot at Fort Worth. When a close friend, Captain Jerry Marshall, crashed in Arkansas in landing an airplane, Phillips immediately set to work on his prize winning idea—an improved method of blind landing. He studied nights, gave up car, vacations and other pleasures for necessary equipment. His wife predicts most of the prize money will be spent for new equipment. He has three children, Patricia, 7; Kenneth, 4; James, 8 months.

The men and management of Revere Copper and Brass Incorporated are proud that the first Award of $5,000 goes to a man like Phillips. We also wish to thank the thousands of other American workmen for their splendid loyalty and cooperation in this effort to speed up industrial defense. Revere Copper and Brass Incorporated, 230 Park Avenue, New York.

TABLE 8—Summary of Engine Effects as Related to Fuel Properties

FUEL PROPERTY	Limits of Investigation	Starting	Smoothness	Smoke	Exhaust Odor	Power	Fuel Consumption	Combustion-Chamber Deposit
Ignition quality (cetane number)	33.2-56.1	Direct relation. Increase in cetane number improves starting.	Direct relation. Increase in cetane number improves smoothness.	Relation apparent. Data indicate a minimum cetane value for specific condition. Increase from this point shows no improvement.	Direct relation indicated. Increase in cetane number results in decreased exhaust-odor objectionability.	No apparent relation.	No apparent relation.	Relation indicated. Decreased deposits with increase in cetane number.
Volatility (ASTM): 90-percent point, °F.	449-672	No apparent relation.	Some relation indicated. Decrease apparently detrimental, although not conclusive.	Direct relation. Lower volatility results in more smoke.	No apparent relation.	No specific independent relation indicated.	No specific independent relation indicated.	Relation indicated. Deposits increase with decrease in volatility.
End point, °F.	487-729							
Flash point (Pensky-Martens), °F.	157-258				No independent data.			
Viscosity at 100 °F: Saybolt, Universal, seconds.	31-51	No apparent relation. Data scattered.	Some relation indicated. Viscosity increase appears detrimental, although not conclusive.	Relation indicated. Increase results in more smoke. Probably a reflection of volatility.	No independent data.	No specific independent relation indicated.	No specific independent relation indicated.	Relation indicated. Deposits increase with increase in viscosity. Probably interrelated with volatility.
Kinematic, centistokes	1.64-7.81							
Gravity, deg. API	26.6-40.8	No apparent relation.	No apparent relation.	Relation indicated. Increase results in more smoke. Probably a reflection of volatility.	No independent data.	Direct relation. Probably due to thermal value of fuel.	Direct relation. Probably due to thermal value of fuel.	Relation indicated. Correlation probably due to interrelated characteristics.
Heating value, Btu per gal.	135,452-143,347							
Carbon residue (10 percent bottoms), percent	0.027-0.21	No relation.	No relation.	Relation indicated. Decrease results in slight improvement.	No independent data.	No relation.	No relation.	Relation indicated. Decrease results in slight improvement.
Modified ASTM gum: Hercules gum-residue test.		No relation.	No relation.	Relation indicated. Decrease results in slight improvement.	No independent data.	No relation.	No relation.	Relation indicated. Decrease results in slight improvement.
Sulfur, percent	0.07-0.60				No independent data.			

starting, engine smoothness, exhaust smoke, exhaust odor, and combustion-chamber deposits.

2. The volatility of the fuel (ASTM distillation) affects smoke and engine deposits.
3. The viscosity (Saybolt Universal seconds) affects smoothness and smoke. The importance of viscosity was recognized in the basic research program as involving the consideration of ease of circulation, atomization, penetration, injection pump-plunger leakage, lubrication quality, heat content, volatility, and overall power output. The data on power output show a decrease in power with a decrease in viscosity, which may be caused in part by the effect of viscosity.
4. The gravity (API) affects smoke, power, and fuel consumption.
5. The carbon residue on 10 percent bottoms (ASTM) affects smoke and combustion-chamber deposits.

This paper is a report of the cooperative full-scale testing carried out by the CFR Full-Scale Engine Group to date. It is hoped that the results of this initial series of tests will serve as a basis for further study which will add to the knowledge of the automotive diesel-engine fuel requirements.

APPENDIX "A"

Recommendations on Required Diesel-Fuel Characteristics

In view of the need for a universal diesel fuel suitable for mobile army and certain high-speed navy equipment, the data and advice available to the Automotive Diesel-Fuels Division of the Cooperative Fuel Research Committee have been analyzed, and are offered as an aid in the development of the specification for such a fuel. The ASTM D-2 fuel-oil specification was reviewed, and it was agreed generally by this group that, due to the recent developments in high-speed diesel engines as well as a more complete understanding of the effect of certain fuel characteristics on engine performance, some revision of the ASTM D-2 specification may be desirable.

Any fuel specification which must take into consideration the availability of base stocks from the greatest possible number of sources, and which must apply to fuel suitable for a variety of types of engines, of necessity must be a compromise if a single specification is mandatory.

The following is a résumé of a series of discussions of the more important fuel variables. The discussions on the several items by the cooperating members were based on information available from the cooperative full-scale engine tests, laboratory data, and field experience.

Viscosity

The importance of viscosity was recognized in the basic research program of the division as involving the consideration of ease of circulation, atomization, penetration, injection pump-plunger leakage, lubrication quality, heat content, volatility and, finally, overall power and economy. Although viscosities lower than 35 sec Saybolt Universal viscosity at 100° F. tend to decrease the power output at a given pump setting due to plunger leakage and inherently lower heat value, in order to broaden the base of fuel supply a lower limit of 33 sec is considered practical for high-speed diesel engines. In any case, when worn pumps are encountered, resetting the pumps in most cases will restore the maximum power available, if the power loss is due to plunger leakage. It is recognized further that, when operations are anticipated in a given area at atmospheric temperatures below an average daily minimum of plus 10° F., the necessity of reaching correspondingly lower pour points may require a further lowering of the viscosity, in which case a viscosity of 31 sec is justified. It is understood that these viscosity values will be determined by the kinematic method, defined by ASTM method D-445-39T, and converted to Saybolt Uni-

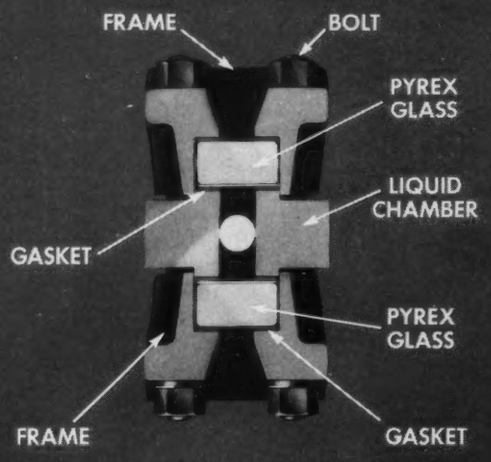
PENBERTHY

DROP FORGED STEEL

TRANSPARENT

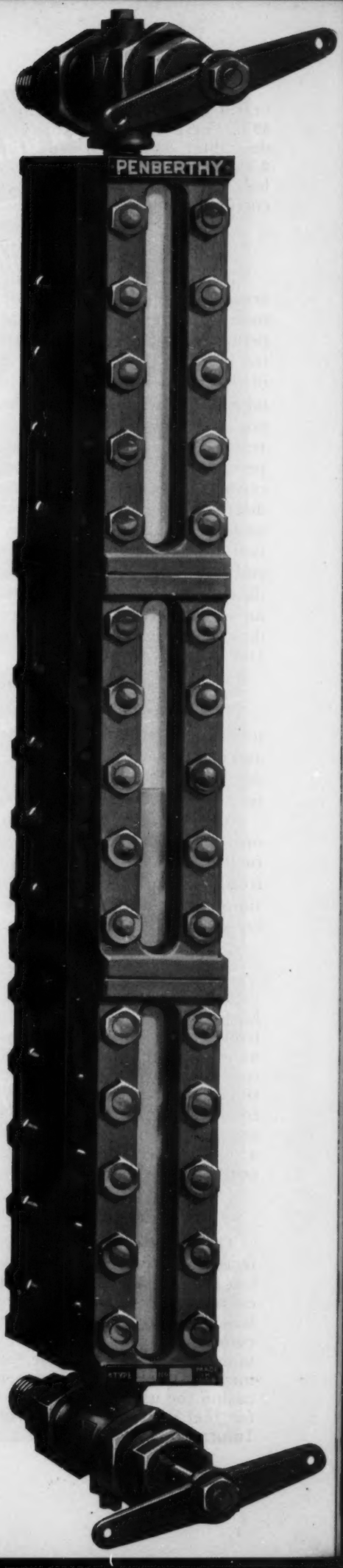
LIQUID LEVEL GAGES

To observe the color or density of liquids under high pressures and/or temperatures



Made of alloy temperature resisting steel. Liquid chamber for single or multiple section gage is made of a solid block of steel the full width of frame to assure perfect alignment and rigidity. Frame has an extra heavy beam at each end and glass chamber is accurately machined to the contour of the glass providing full metal backing for the gaskets. Pyrex glass has greater resistance to thermal shock and erosion.

These gages are available in any length and for various pressures and temperatures. We shall be glad to quote upon your requirements. Write for new Catalog 34-A.



PENBERTHY INJECTOR COMPANY

DETROIT, MICHIGAN

PENBERTHY PRODUCTS

CANADIAN PLANT:
WINDSOR, ONTARIO

versal viscosity according to ASTM method D-446-39T. The following viscosity values, therefore, seem desirable: 33 sec Saybolt Universal viscosity, i.e., 2.11 centistokes viscosity, minimum, and 43 sec Saybolt Universal viscosity, i.e., 5.22 centistokes viscosity, maximum, at 100° F.

Volatility

The upper limit of the boiling range will be governed by the requirements of the high-speed automotive-type engines. The wide speed, load, and temperature variations encountered in this type of service indicate the desirability of complete distillation of the fuel below 700° F. To insure minimum smoke, odor, lubrication-oil contamination, and engine deposits, it will be necessary to prevent undue concentration of heavy ends in the fuel. Therefore, a 90-percent point (ASTM) at 650° F. should not be exceeded. Inasmuch as the minimum flash point, to be discussed later, will tend to control the permissible amount of the undesirable low-boiling fraction in the fuel, it is not thought necessary to define the lower end of the boiling range. Summarized, this would indicate a 90-percent point at 650° F., maximum, and an end point at 700° F., maximum, for a universal diesel fuel, when determined by ASTM method D-86-35.

Flash Point

The smoothness-of-combustion and fire-hazard factors in some way are related to the low-end volatility, and can be defined most conveniently by a flash point determined according to the Pensky-Martens closed tester, ASTM method D-93-36.

Available information indicates that satisfactory operation, from this consideration, is possible with fuels having flash points lower than 140° F. To insure freedom from operational difficulty in military operations, a flash point of 140° F. should prove to be a conservative minimum.

Carbon Residue

Definition of that fuel property which affects combustion-chamber and nozzle deposits usually is controlled by the volatility limitation. However, to eliminate unusual products which might have excessive concentrations of residue within the allowable volatility range, a carbon-residue test on 10 percent bottoms by ASTM method D-189-39 is considered necessary. Performance studies indicate that fuels having a residue not in excess of 0.15 percent of the 10 percent residuum have proved satisfactory.

Ignition Quality

The ease with which a diesel fuel auto-ignites affects not only the general combustion in the engine, but also its starting characteristics. As a bulk of the commercially available fuels will have cetane values less than 60, no upper limit of ignition quality was considered. It is recognized generally that high cetane values are desirable, but available fuel stocks meeting the other requirements herein expressed occasion the use of a 47-cetane minimum value at least for fuel stocks available from certain supply areas. Information available on a majority of the engine types used, operating under a wide range of conditions, indicates satisfactory performance on fuels of at least 47 cetane value, and this should prove a satisfactory minimum value for a universal military fuel.

Pour Point

The pour point of a fuel oil is of triple importance, affecting in cold weather:

1. The bulk handling of the fuel.
2. The pumpability of the fuel in the engine.
3. The fuel filter performance at low temperatures.

In view of the fact that the best fuels from an ignition angle tend to have poor cold-weather characteristics, the pour point should not be specified lower than absolutely necessary. In order to obtain adequate supplies of fuels having the other necessary properties outlined herein, it is advisable that a universal fuel for general military use have a pour point of 0° F. As the majority of commercially available fuels have a cloud point approximately 10° F. above the pour point, and as the cloud point limits the flow through the filter, a safe operating temperature for a 0°-F.-pour-point fuel would be +10° F. In those sections of the country where the average daily minimum temperature is below +10° F., it will be necessary to use fuels of correspondingly lower pour point. Under such conditions a corresponding adjustment of the minimum viscosity may be found necessary, as discussed under viscosity, hereinbefore.

Ash

The Conradson carbon-residue limit of 0.15 percent on 10 percent bottoms in itself will limit the ash content, because that test will indicate ash in addition to carbonaceous material. A separate limitation on ash alone, therefore, would be superfluous.

Water and Sediment

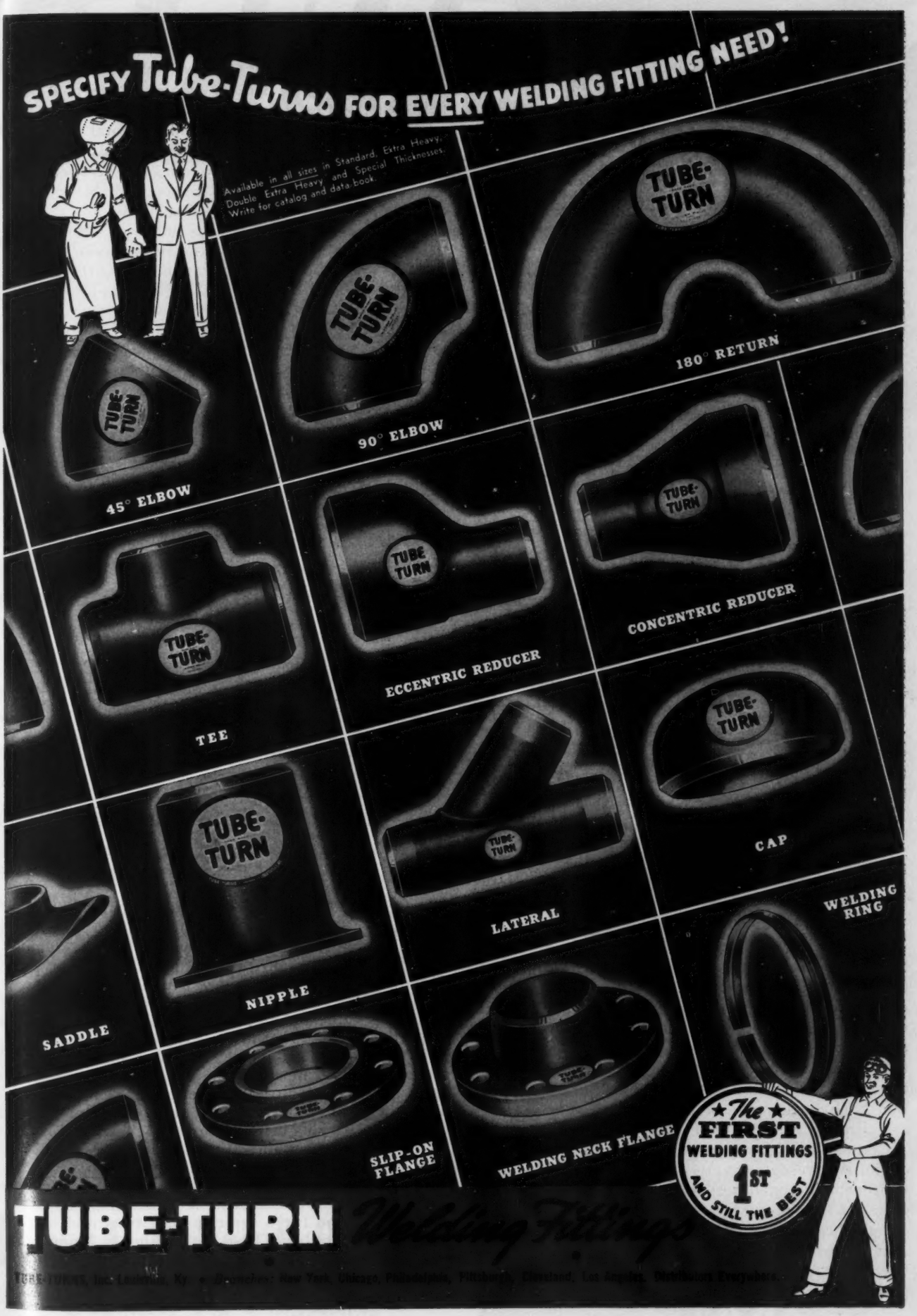
Although the committee's program has added little to existing data on the importance of keeping water and sediment within negligible amounts, all reported experience appears to indicate that the value of 0.05 percent maximum (as incorporated in specifications already in use) is satisfactory, and in no way limits supplies or works hardship on any refiner—the water-and-sediment determination to be made according to ASTM method D-96-35.

Sulfur

Although the evidence regarding the absolute maximum limit for sulfur is inconclusive, experience indicates that a maximum value of 1.0 percent by ASTM method D-129-34 is satisfactory from the user's standpoint, and such a limit has the value of permitting the use locally—in those sections of the country where only high-sulfur fuels can be manufactured—of fuels produced in that territory. A low value would exclude the use of such fuels, and thereby limit the total available supply.

Corrosion

As a protection against corrosion difficulties in fuel lines of various compositions, it is considered desirable to require a 3-hour copper-strip test at 212° F.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In this test a "peacock color" is to be interpreted as an indication of "tarnish," but not corrosion; i.e., a fuel giving a "peacock color" shall be considered satisfactory. A darker color is to be interpreted as unsatisfactory and not acceptable.

APPENDIX "B"

Exhaust-Odor Rating of Diesel Fuels

(The Texas Company, Beacon, N. Y., Laboratory)

The complete combustion of the hydrocarbons supplied to any internal-combustion engine should result in exhaust gases which are practically free of objectionable odors. However, many factors may prevent the complete oxidation process, with the resultant discharge of partly burned or oxidized hydrocarbons with the exhaust—giving rise to observations and complaints of smoke and objectionable odors. It has been shown that, at an intermediate step in the combustion reactions for normal hydrocarbon fuels, various aldehydes are formed. In their separate state, some of these aldehydes are well known to have an acrid, pungent odor, producing more or less intense irritation of the eyes and respiratory system. It was, therefore, logical that some experimenters should use the aldehyde content of engine exhaust gases as a practical measure of their objectionability.

Because the operation of diesel-engine city buses obviously presents a very critical source of exhaust-odor complaints, observations were made to determine the type of operation producing the most objectionable conditions. A number of observers agreed that the later stage of deceleration prior to stopping, the idling period, and the subsequent acceleration period produced the greatest quantity and most objectionable fumes and, also, consistently distinguished differences between fuels having not very greatly different physical characteristics. Subsequent laboratory tests, using a similar engine, confirmed the field tests, and established that very good agreement existed between "sniff" tests and the total aldehyde content of the exhaust sample. Figure 23 illustrates the typical correlation between observer reaction and total aldehydes, expressed as formaldehyde in milligrams per cubic foot of exhaust gas.

Extensive dynamometer tests indicated, on the particular engine used, that the exhaust-aldehyde content was greatest at idling—diminishing at part throttle and increasing at full throttle, as illustrated in Figure 23. As the idling condition appeared most critical, tests were made on a wide range of fuels to determine the minimum fuel rate which would permit smooth idling. Figure 24 indicates that the cetane value of the fuel controls the minimum quantity injected which will give uniform combustion. Obviously, decreasing the fuel rate for a given fuel below its minimum value indicated would result in discharge of partly oxidized fuel to the exhaust, with resultant objectionable odors. This curve also indicates that under these specific conditions a rather wide range of fuel volatility had little or no effect.

For a specific injection rate, the exhaust-aldehyde content for varying cetane number is shown in Figure 22 for an engine running at no load at a speed of 1400 rpm, and for an engine idling at 350 rpm.

As exhaust odor objectionability is a function of the completeness of combustion of the fuel, it appears logical that the fuel's ignition quality would be its controlling variable. These data, although limited in scope, seem to confirm the generalization that fuel cetane value is the principal variable in control of odor.

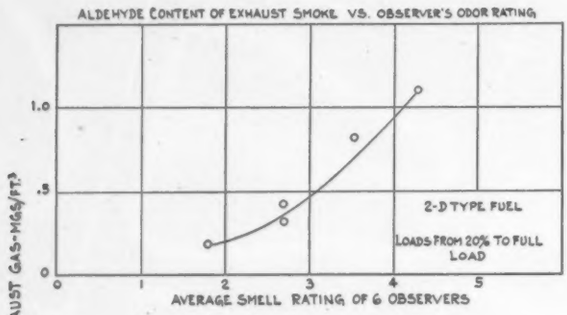


FIGURE 23

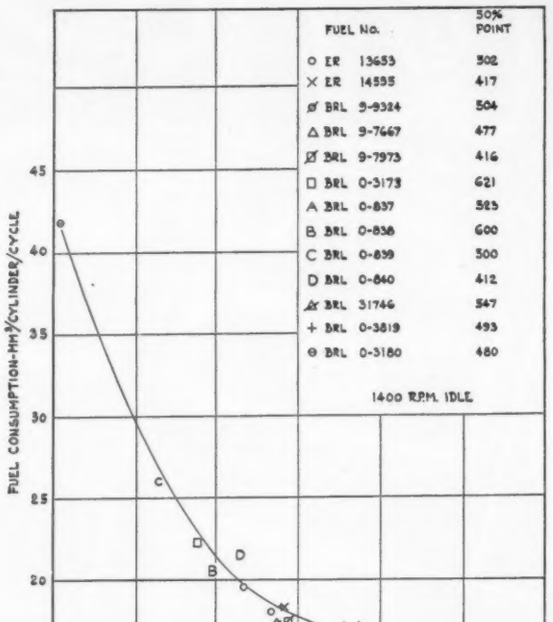
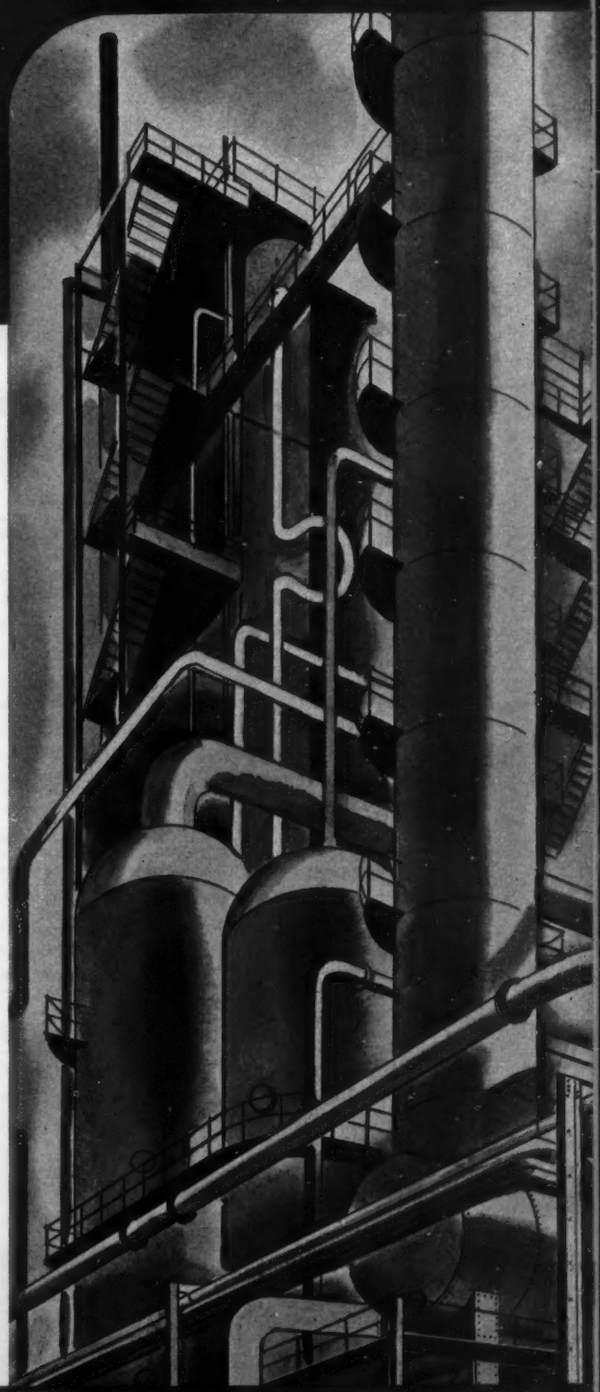


FIGURE 24

Fuel Consumption vs. Cetane Number

FLEXIBILITY

the keynote of profitable oil refinery operation . . .



THE ability to switch quickly and without expense from one refining operation to another is vitally necessary to meet changing market demands at a profit.

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The best guarantee of efficient *flexible* refinery operation is McKee engineering.

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Record Demand and Moderate Stocks Make Situation Good

L. J. LOGAN

THE oil industry has entered upon the second half of this extraordinary year in a generally satisfactory position and without formidable problems, aside from transportation difficulties which have arisen because of the war and the defense program but which are being minimized through efforts of the industry, with government cooperation.

Oil companies are doing this year the greatest volumes of business they ever did, as total demand for petroleum is running higher than ever before, despite sharply subnormal exports.

Available supply, from current production, imports, and stocks, is in favorable relation to the prevailing demand, moreover, and favorable markets for both crude and refined oils consequently obtain.

Through advances since the beginning of the year, crude prices have improved to the best levels since the fall of 1938, and prices of refined products have recovered to the highest levels since the fall of 1937.

Earnings of oil companies reflect these favorable circumstances in which record quantities of crude oil are being produced and refined and in which relatively good prices are being obtained for the large volumes of crude and products marketed.

In the first quarter of this year, aggregate earnings of the industry failed to equal those of the corresponding period last year. But as the second quarter commenced, prices of crude oil and refined products materially improved, and as the period advanced, additional improvement occurred, with the result that June-quarter profits of 1941 were generally better than those of 1940. For the first six months of 1941 as a whole, earnings probably were appreciably better than those of the corresponding months of last year.

Similarly, the latter half of this year very likely will afford materially better earnings than did the like period last year, when prices of gasoline were depressed practically as low as during the depression and when markets for lubricants and some other finished products likewise were exceptionally weak.

Advances of prices of crude oil and refined products have been well in line with increases in prices of other commodities, and consequently, although the government currently is discouraging any further raising of prices in the oil industry, as well as in other industries, there is certainly no justification for any special questioning of the present prices of oils. Whereas prices of raw materials in general, as represented in the Depart-

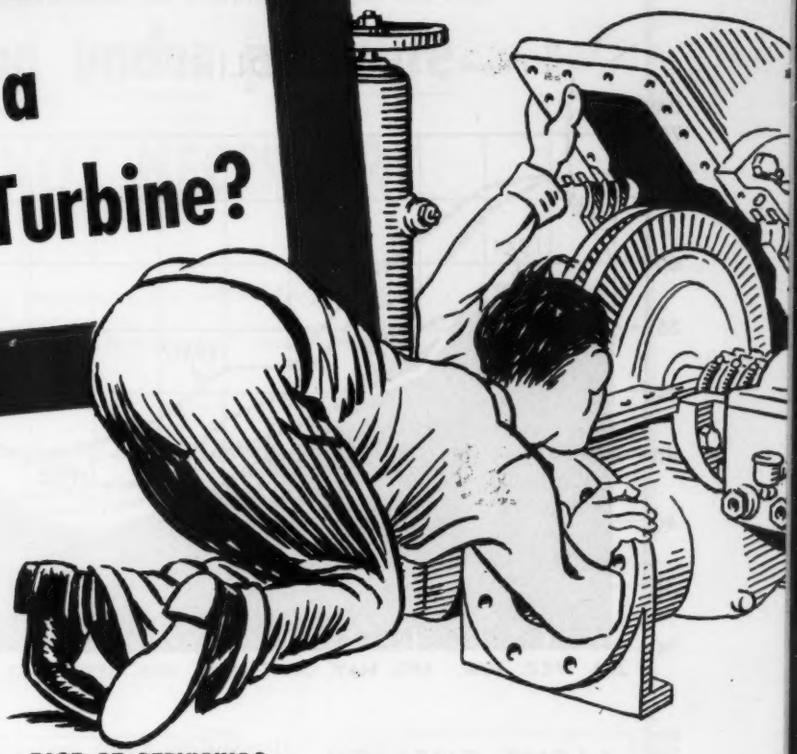
Petroleum Demand Up Nearly 6 Percent This Year

Figures indicate barrels, and are from Bureau of Mines

	APRIL			FIRST FOUR MONTHS		
	1940	1941	Percent Change	1940	1941	Percent Change
SUMMARY—						
Total Demand	115,303,000	127,053,000	+ 10.2	471,124,000	494,124,000	+ 4.9
Daily average	3,843,000	4,235,000	+ 10.2	3,894,000	4,120,000	+ 5.8
Exports:						
Crude petroleum	4,262,000	2,503,000	— 41.3	15,837,000	7,520,000	— 52.5
Refined products	7,585,000	[1]5,900,000	— 22.2	27,659,000	21,035,000	— 23.9
Total exports	11,847,000	8,403,000	— 29.1	43,496,000	28,555,000	— 34.4
Domestic Demand:						
Total domestic demand	103,456,000	118,650,000	+ 14.7	427,628,000	465,839,000	+ 8.9
Daily average	3,449,000	3,955,000	+ 14.7	3,534,000	3,882,000	+ 9.8
TOTAL DEMAND FOR PRODUCTS:						
Motor Fuel:						
Domestic	47,683,000	55,105,000	+ 15.6	170,217,000	191,265,000	+ 12.4
Exports	2,075,000	[2]2,288,000	+ 10.3	8,517,000	7,742,000	— 9.1
Total	49,758,000	57,393,000	+ 15.3	178,734,000	199,007,000	+ 11.3
Aviation Gasoline:						
Domestic	671,000	812,000	+ 21.0	2,029,000	2,405,000	+ 18.5
Exports	410,000	[3]63,000	— 84.6	1,203,000	1,355,000	+ 12.6
Total	1,081,000	875,000	— 19.1	3,232,000	3,760,000	+ 16.3
Kerosene:						
Domestic	5,621,000	5,549,000	— 1.3	25,799,000	26,623,000	+ 3.2
Exports	399,000	180,000	— 54.9	1,573,000	519,000	— 67.0
Total	6,020,000	5,729,000	— 4.8	27,372,000	27,142,000	— 1.0
Gas & Oil Distillate Fuels:						
Domestic	11,849,000	[4]12,634,000	+ 6.6	68,121,000	71,105,000	+ 4.4
Exports	1,966,000	[5]956,000	— 51.4	7,067,000	4,379,000	— 38.0
Total	13,815,000	13,590,000	— 1.6	75,188,000	75,484,000	+ 0.4
Residual Fuel Oils:						
Domestic	26,887,000	[6]31,452,000	+ 16.9	117,671,000	128,442,000	+ 9.2
Exports	1,532,000	1,378,000	— 10.1	4,372,000	4,561,000	+ 4.3
Total	28,419,000	32,830,000	+ 15.5	122,043,000	133,003,000	+ 9.0
Lubricants:						
Domestic	2,138,000	2,172,000	+ 1.6	7,597,000	9,140,000	+ 20.3
Exports	1,161,000	775,000	— 33.0	4,511,000	8,363,000	+ 85.4
Total	3,299,000	2,947,000	— 10.7	12,108,000	17,503,000	+ 44.6
Wax (thousands of pounds:)						
Domestic	29,537	51,997	+ 76.0	101,095	155,423	+ 53.7
Exports	19,156	[7]11,933	— 37.7	94,207	49,878	— 47.1
Total	48,693	63,930	+ 31.3	195,302	205,301	+ 5.1
Coke (short tons):						
Domestic	72,700,000	86,200,000	+ 18.6	456,100,000	514,800,000	+ 12.9
Exports	27,500,000	17,000,000	— 38.2	63,300,000	53,800,000	— 15.0
Total	100,200,000	103,200,000	+ 3.0	519,400,000	568,600,000	+ 9.5
Asphalt (short tons):						
Domestic	302,000,000	385,800,000	+ 27.7	849,000,000	1,119,900,000	+ 31.9
Exports	29,400,000	23,300,000	— 20.7	91,700,000	77,800,000	— 15.2
Total	331,400,000	409,100,000	+ 23.4	940,700,000	1,197,700,000	+ 27.3
Road Oil:						
Domestic demand	190,000	192,000	+ 1.1	501,000	447,000	— 10.8
Miscellaneous:						
Domestic	156,000	193,000	+ 23.7	554,000	978,000	+ 76.5
Exports	85,000	68,000	— 20.0	462,000	205,000	— 55.6
Total	241,000	261,000	+ 8.3	1,016,000	1,183,000	+ 16.4

[1] Beginning April, 1941, data concerning shipments to and from noncontiguous territories not available. [2] Includes 11,000 barrels benzol and 760,000 barrels exported from bond. [3] Includes 5,000 barrels antiknock compounds. [4] Includes 749,000 barrels Deisel bunker oil. [5] Includes 80,000 barrels exported from bond. [6] Includes 1,871,000 barrels bunker fuel oil. [7] Includes 154,000 pounds exported from bond.

What Do YOU Look for in a Mechanical-drive Turbine?



LOW-COST BY-PRODUCT POWER?

You have it—24 hours a day, 7 days a week—when you use General Electric's Type D turbines, because they provide an economical drive for general-purpose apparatus and power-plant auxiliaries. Simultaneously, they supply low-pressure steam for process or seasonal heating. Unreclaimable losses are less than five per cent. Nozzles correctly proportioned, buckets contoured to approximate the steam expansion characteristics, low-loss packing glands—all to get more work from the energy in a pound of steam. And, where over-all plant economy is important, mechanical-drive turbines save again because of the low maintenance expense and small amount of attention required.

CLEAN STEAM FOR PROCESS?

Because no lubrication is required in the steam passages of a turbine, you can be sure of oil-free steam.

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In our improved Type D's you can be sure of *positive protection* against overspeed. If for any reason speed becomes excessive, an emergency trip device operates to instantly close a built-in combined trip and throttle valve that shuts off all steam flow. Here's complete safety available as a standard feature. Turbine drives can also be used safely in inflammable and explosive atmospheres.

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Without "time out" for maintenance or repairs, G-E turbines keep going to meet today's demands for continuous performance. They keep going even when adverse operating conditions exist, such as unusually high ambient temperatures or excessively moist atmospheres. And, in dual-drives, turbines either pick up the load instantly when called upon to do so or divide the load with the motor for the most economical heat balance.

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Because of their adaptability to any speeds within wide limits and the availability of reduction gear units, turbine drives permit operation of the driven equipment at its most efficient speed. Turbines built for one steam pressure can usually be adapted to another pressure by minor changes.

EASE OF SERVICING?

Take out one linkage pin, remove eight bolts, lift the valve bonnet—in less than two minutes you have completely exposed the inlet valve for inspection. Want to clean the steam strainer? There's no need to break the station piping or remove the governor valve in the improved Type D. Does the carbon packing need adjusting? Detachable boxes and garter springs make it easy. All pipe connections are made to the lower half so that the cover can be easily removed for inspection of internal parts.

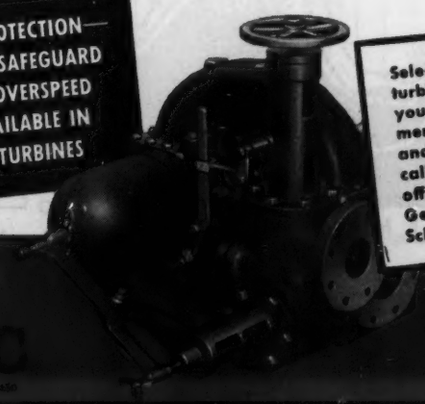
LOW INITIAL COST?

For what you would pay for an ordinary turbine, you can obtain a Type D with positive overspeed protection, improved bearing cooling, and built-in throttle valve. Remember, production line manufacturing, made possible by the widespread demand for this turbine, means more for your turbine dollar.

MINIMUM MAINTENANCE EXPENSE?

It's attention to details that builds reliability—and keeps maintenance costs low—in G-E turbines. Bucket and valve materials are carefully selected for resistance against corrosion and erosion; bearings are water-cooled to give low operating temperatures; packing glands are made of carbon for long life and infrequent attention.

POSITIVE PROTECTION—AN ADDED SAFEGUARD AGAINST OVERSPEED NOW AVAILABLE IN TYPE D TURBINES

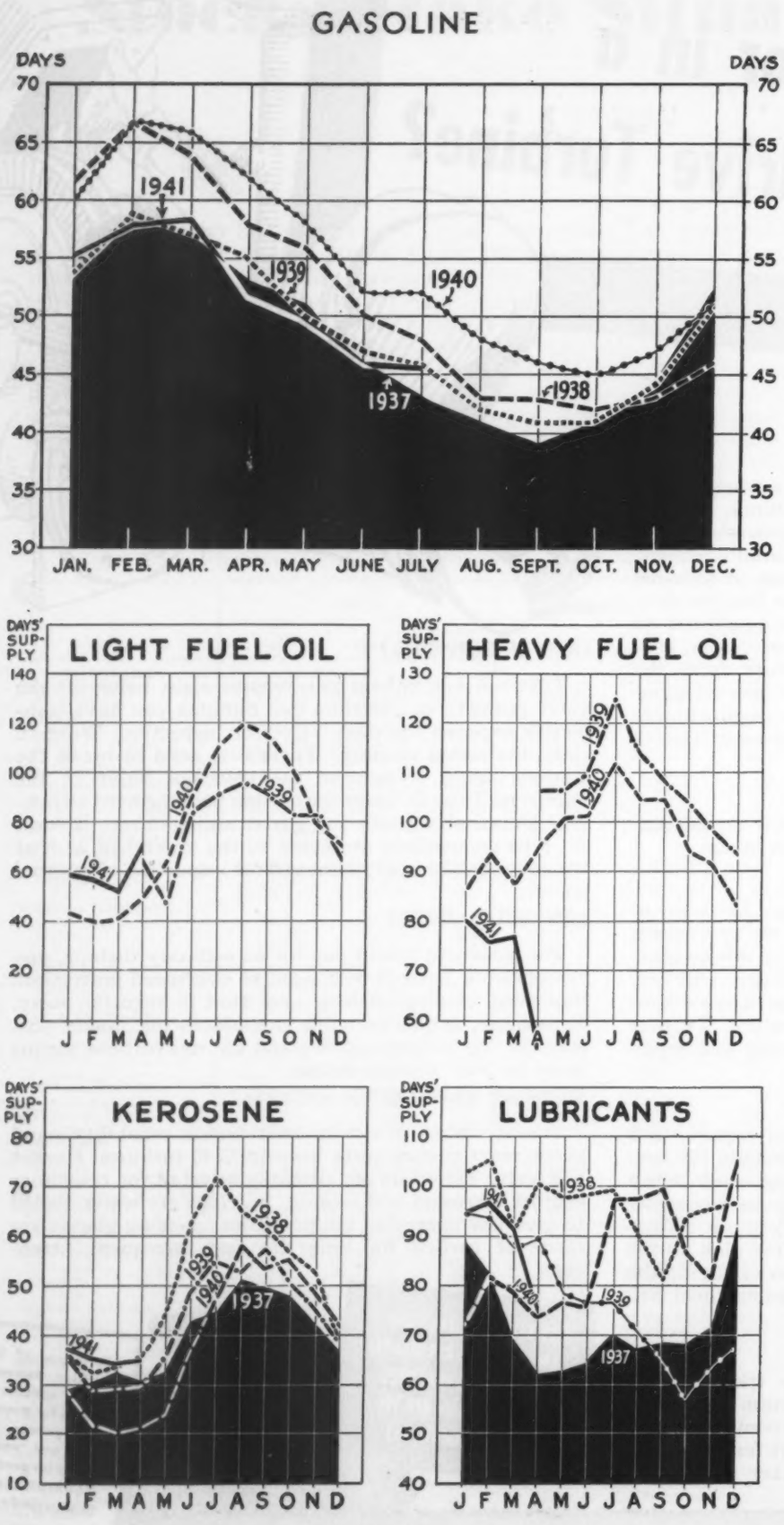


Selection of the right turbine depends upon your specific requirements for process steam and power. Why not call our nearest G-E office for practical help? General Electric Co., Schenectady, New York

GENERAL ELECTRIC

Days' Supply of Principal Refined Products in Storage

In relation to prevailing consumption, stocks of gasoline are about same as in 1937; those of heavy fuel oil are exceptionally low; and inventories of kerosene, light fuel oil, and lubricants are moderate.



ment of Labor's index of 815 commodities at wholesale, have increased 20 per cent since a year ago, crude oil has advanced only about 15 percent. And while manufactured commodities in general have increased 10½ percent, the wholesale price of gasoline to the dealer has improved only in exactly that same amount, from its seriously depressed level a year ago.

There is a possibility, in fact, that because of the government's efforts to hold down prices of crude oil and refined products, the earnings possibilities of the industry may be circumscribed. For unless the government also holds down wages and the costs of materials used by the industry, the oil companies will find it difficult or impossible to escape a narrowing of the margins of profit.

Demand Greatest on Record

Total demand for petroleum has been running this year well above any previously reached level, as unprecedented domestic consumption has more than compensated for loss of export business.

In April, latest month for which official figures on demand are available, total demand for oil was 10 per cent larger than in that month last year, as domestic consumption was up almost 15 percent, while exports were down 29 percent.

Total demand for petroleum in the first four months of this year was almost 6 percent larger than in the like months last year, on a daily average basis, with domestic use up 10 percent and exports down 34 percent.

Consumption trends of the first four months of this year have been extended without radical change through May and June and into July, as evidenced by the fact that the Bureau of Mines forecast for each of the latter three months about the same gain over a year before as for the earlier months of the year in domestic demand for gasoline, principal product of the industry.

It has been recognized that scarcity of tankers for moving oils from the Gulf Coast to the Atlantic seaboard may temporarily restrict consumption in the latter region, but so far, the East Coast oil shortage has remained merely a threat rather than a reality. Various means have been used to avoid or at least postpone actual inadequacy of gasoline in the Eastern

It's TOUGH working under pressure—
and often it's NOT NECESSARY

Many high temperature heating problems are solved by modern processing operations based on the Dowtherm* *low pressure* method of heat transfer.

Dowtherm (B.P. 500° F.) is employed in over 200 commercial installations wherein accurately controlled high temperatures are maintained under low pressures—pressures that even at 700° F. do not exceed 110 lb./sq. in. These systems are readily adaptable to automatic operation, thus simplifying a very important phase of the processing problem.

Industries including resin processing, paint and varnish manufacture, vegetable and mineral oil refining were among the first to adopt Dowtherm method of heat transfer as the solution to their high temperature processing problems. If your processes also require high temperature, investigate Dowtherm.

*Trade Mark Reg. U. S. Pat. Off.

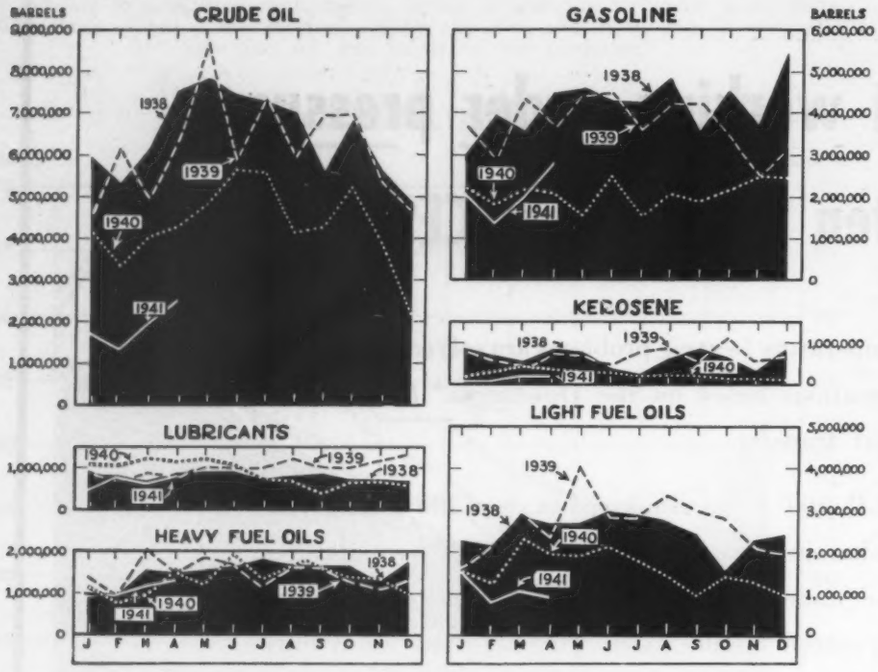
DOWTHERM

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York, St. Louis, Chicago, Seattle, San Francisco, Los Angeles, Houston

Working with you for America

U. S. Exports of Crude Petroleum and Refined Products



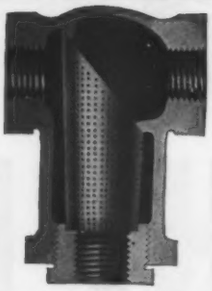
States, and during the past six weeks there have been contra-seasonal additions to gasoline stocks in those states. Actually, the gasoline inventory situation on the East Coast has been improved, therefore, rather than impaired. This result has been achieved, in the face of the loss of 20 percent of the industry's tanker facilities, through the transfer of 50 boats to British service, by making more efficient the use of tankers that remain, by increasing pipe line movement of crude oil from the Southwest to the New York and Philadelphia areas, by increasing shipments by tank car and barges, and more recently by the Navy's temporary returning to the industry of two large, new tankers that had been taken out of civilian use and put into naval service. Meanwhile, additional tankers are being built, and expansion of pipe line facilities between the Southwest and the East is being pushed.

The contra-seasonal building up of gasoline stocks on the East Coast has been achieved partly at the expense of coastwise movement of fuel oils, gasoline having been given precedence over the fuel oils in loading available boats, because of more immediate demand. However, through this procedure, there has been avoidance so far of any real shortage of any kind on the East Coast. And it is contemplated that heavy demand for heating oil on the Atlantic Coast next fall and winter will be similarly met when the necessity comes, for at that time, requirements for gasoline will be easing up, and available transportation facilities may

PIPEWRENCH PETE SAYS:

DO I LOOK LIKE TH' GOLD DUST TWINS?

Nights, and Sundays too, I've put in, fixing regulating valves and controls . . . only to find that dirt and scale was causing the trouble.



Thought I'd ask the boss if I looked like the Gold Dust Twins. Instead, I just got some Strong Strainers and put one ahead of every valve and control. Believe me, they do the job. Now, all I've got to do is open a few blow-off valves, and out comes the dirt and scale.

Send for your copy of Bulletin 154

STRONG

STRAINERS

The Strong, Carlisle & Hammond Company
1392 West Third Street, Cleveland, Ohio

E

Sellers *Hi-Pressure* Cleaning Jet

for FASTER, BETTER CLEANING of Refinery Processing Equipment

A PORTABLE cleaning unit for cleaning heat exchanger bundles, cooling coils, bubble caps, pumps and machinery, barrel heads, etc. — providing a cheaper and better method of cleaning. Utilizing steam at a pressure from 50 to 125 lbs. and water at any pressure over 15 lbs., it produces a jet force from 100 to 270 lbs. and 180 to 190 degrees—two to three times the dirt penetrating force and cutting power of fire lines.

Write for Sellers' illustrated Type R Bulletin.

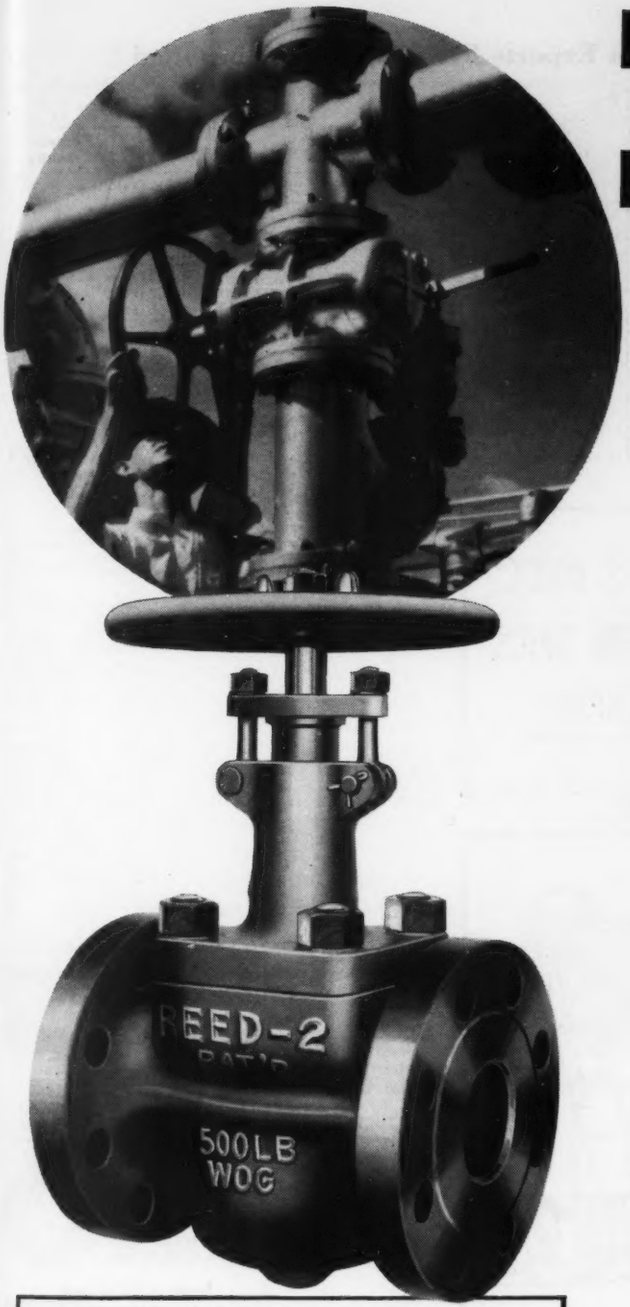
WM. SELLERS & CO., INC.

1609 Hamilton Street, Philadelphia, Pa.

SELLERS 1848

Sellers

KEY YOUR PIPING COSTS TO THE LOW MAINTENANCE COST of REED VALVES



- **Compact Design**
- **Exclusive — easy operating features**
- **Positive shut-off and control**

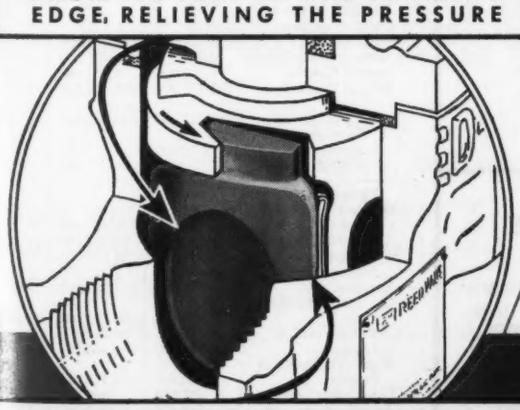
Piping costs are dependent to a great extent upon the correct selection of valves. Low upkeep costs and dependable operation are vital considerations. The Reed Valve is simple and compact in construction and the exclusive design is especially adapted to low maintenance costs.

The disc holder is designed to lift the disc directly away from its seat BEFORE it moves to the open position, providing exceptional ease of operation.

The cleaning action of the disc as it moves to the open or closed position, together with the through-conduit in the disc holder, combine to protect the seats from the erosive effects of entrained foreign particles.

The Reed Valve Catalog 41 may show you the way to lower maintenance costs. Send for your copy NOW.

THE DISC IS LIFTED DIRECTLY AWAY FROM ITS SEAT AT THE TRAILING EDGE, RELIEVING THE PRESSURE



THIS EDGE REMAINS IN CONTACT WITH THE INNER BODY WALL, WIPING THE SURFACE WHEN VALVE IS BEING OPENED

REED VALVE DIVISION
of the REED ROLLER BIT CO.
P. O. BOX 2119 HOUSTON, TEXAS

then be devoted particularly to the meeting of the burning oil demand. Furthermore, some relief may be expected by then from launching of new tankers and construction of new pipe lines and barges.

There have been hints that still more tankers might have to be given up soon for British use, but the industry is hopeful that further requests will be limited to replacements of boats currently sunk, in which event the requirements might be met currently without great shock, as new boats came off the ways.

Petroleum Exports Remain Greatly Curtailed

ITEM	APRIL 1940	APRIL 1941	APRIL Percent Change	FIRST 4 MONTHS 1940	FIRST 4 MONTHS 1941	FIRST 4 MONTHS Percent Change
Crude Oil	4,262,000	2,503,000	— 41.3	15,837,000	7,520,000	— 52.5
Products:						
Motor Fuel	2,075,000	[1]2,288,000	+ 10.3	8,517,000	7,742,000	— 9.1
Aviation Gasoline	410,000	[2]63,000	— 84.6	1,203,000	1,355,000	+ 12.6
Kerosene	399,000	180,000	— 54.9	1,573,000	519,000	— 67.0
Gas Oil & Distillate	1,966,000	[3]956,000	— 51.4	7,067,000	4,379,000	— 38.0
Residual Fuel Oil	1,532,000	1,378,000	— 10.1	4,372,000	4,561,000	+ 4.3
Lubricants	1,161,000	775,000	— 33.2	4,511,000	2,756,000	— 38.9
Wax (thousands of pounds)	19,156	[4]11,933	— 37.7	94,207	49,878	— 47.1
Coke (short tons)	27,500	17,000	— 38.2	63,300	53,800	— 15.0
Asphalt (short tons)	29,400	23,300	— 20.7	91,700	77,800	— 15.2
Miscellaneous Oils	85,000	68,000	— 20.0	462,000	205,000	— 55.6
[6]Total Refined Products	7,585,000	[5]5,900,000	— 22.2	27,659,000	21,035,000	— 23.9
Total Crude and Products	11,847,000	8,403,000	— 29.1	43,496,000	28,555,000	— 34.4

[1] Includes 11,000 barrels benzol and 760,000 barrels exported from bond.
[2] Includes 5000 barrels anti-knock compounds.
[3] Includes 80,000 barrels exported from bond.
[4] Includes 154,000 pounds exported from bond.
[5] Beginning April, 1941, data concerning shipments to and from noncontiguous territories not available.
[6] Not the sum of the above figures, some of which do not indicate barrels.

Having taken into consideration all circumstances and reasonable possibilities, leaders in the industry are generally confident that the transportation problem will not prove insuperable and that there will not be much, if any, actual curtailment of the normal movement of oils to all consumers, despite the fact that consumption is proceeding in record-breaking volume.

Changes From Year Ago in Stocks Of Crude and Refined Oils in the United States

(Figures indicate Barrels)

LATEST WEEKLY DATA

(Sources: Crude stock, Bureau of Mines; all other figures American Petroleum Institute.)

STOCKS OF:	June 29, 1940	June 28, 1941	Percent Change
Gasoline	94,298,000	91,461,000	— 3.0
Gas Oil & Distillate	33,048,000	35,732,000	+ 8.1
Residual Fuel Oil	104,344,000	92,896,000	—11.0
Crude Oil	*260,891,000	†259,142,000	— 0.7

LATEST MONTHLY DATA

(Source: Bureau of Mines.)

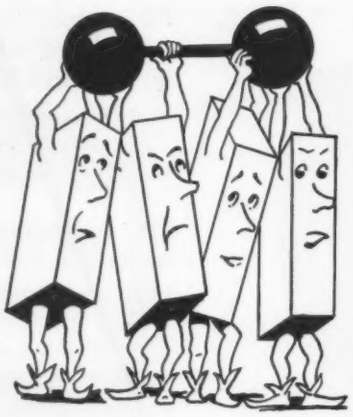
ITEM	Stocks at End of April 1940	Stocks at End of April 1941	Percent Change
SUMMARY—			
Crude Petroleum:			
Refinable in U.S.	258,066,000	266,012,000	+ 3.1
Heavy in California	13,516,000	11,802,000	—12.7
Natural Gasoline	6,112,000	5,504,000	— 9.9
Refined Products	277,739,000	273,439,000	— 1.5
Total, all Oils	555,433,000	556,757,000	+ 0.2
Days' Supply:			
April basis	145	131	— 9.7
4 Months basis	143	135	— 5.6
PRODUCTS—			
Gasoline:			
Finished	96,615,000	88,576,000	— 8.3
Unfinished	6,112,000	5,504,000	— 9.9
Total	102,727,000	94,080,000	— 8.4
Aviation Gasoline	5,178,000	7,347,000	+41.9
Kerosene	4,351,000	7,063,000	+62.3
Gas Oil & Distillate Fuels	25,092,000	31,793,000	+26.7
Residual Fuel Oils	88,932,000	80,379,000	— 9.6
Lubricants	8,065,000	8,363,000	+ 3.7
Wax (Thousands of Pounds)	96,910	116,096	+16.5
Coke (short tons)	663,000	400,000	—39.7
Asphalt (short tons)	768,000	933,000	+21.5
Road Oil	1,145,000	1,047,000	— 8.6
Miscellaneous	407,000	459,000	+12.8
Other Unfinsihed Oils	38,299,000	40,857,000	+ 6.7

* Stocks June 22, 1940.
† Stocks June 21, 1941.

"WHEN 1 ARMSTRONG'S BRICK DOES THE WORK OF 4 FIRE BRICK . . . THAT'S EFFICIENCY!"

SURE I'm proud—I'm an efficient Armstrong's Insulating Fire Brick, and I *can* do the work of four regular fire brick. Here's what I mean:

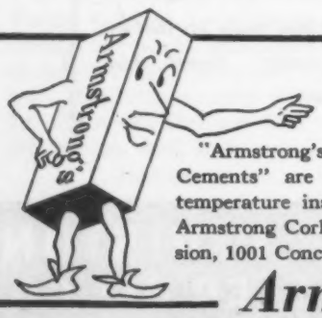
To begin with, I'm light in weight but designed both for insulating efficiency and to give lasting service. I have ample strength to withstand shipping and handling bumps and I can be used either for backing up or directly exposed to hot furnace gases.



Engineers take full advantage of my efficiency and strength to simplify furnace design. They use thinner walls, reduce quantities of refractories, and save weight throughout the job when I'm included.

Then, too, I store a lot less heat than regular fire brick—less than one tenth as much in many cases—I can heat up and cool off almost ten times as fast as fire brick and that saves a lot of valuable time on batch operations.

I'm made in five classes for temperatures up to 2600° F. In standard sizes I may be notched, grooved, and shaped with a saw or rasp right on the job, making it unnecessary to keep a stock of special shapes for repairs.



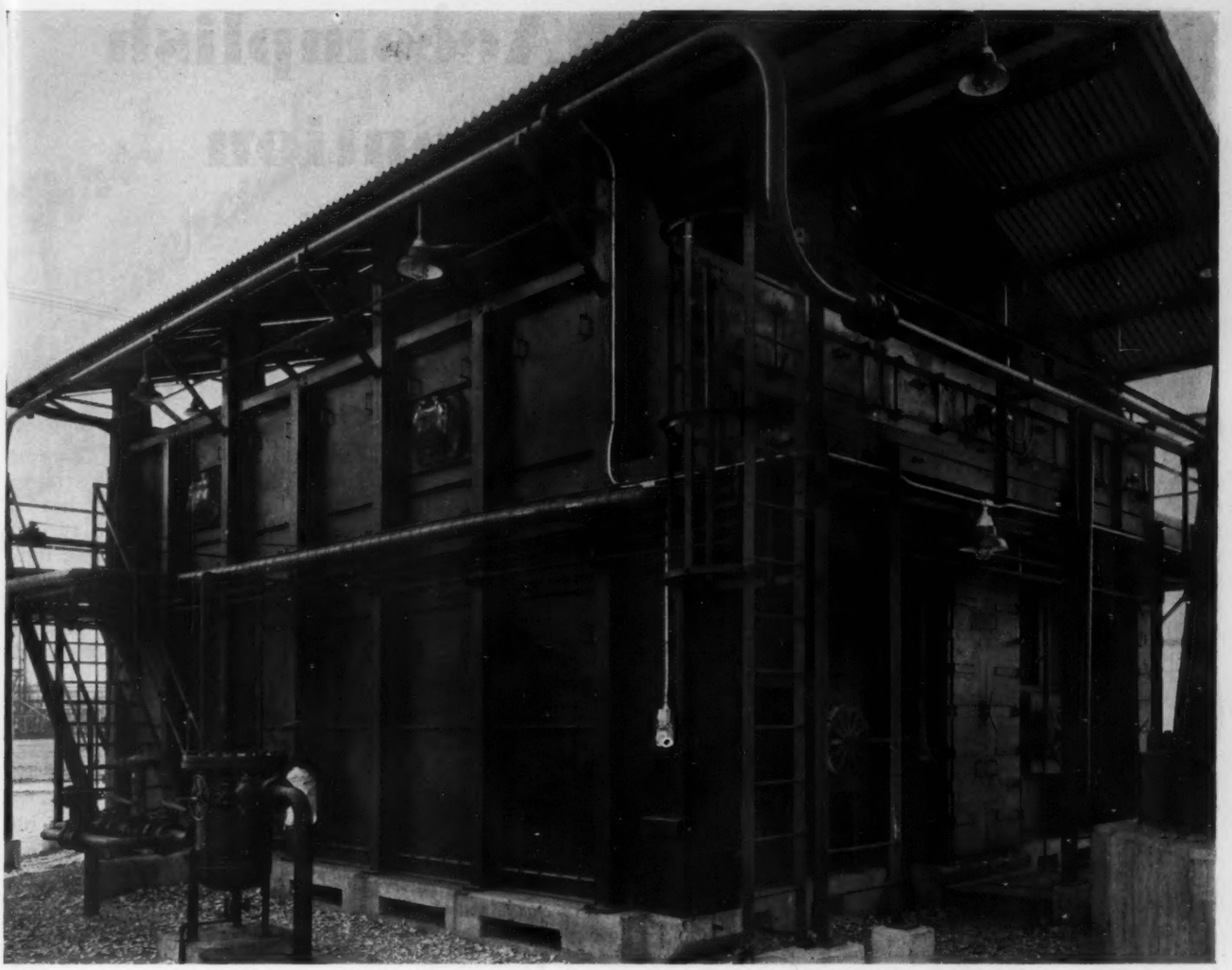
"YOU'LL WANT THESE TWO NEW BOOKS"

"Armstrong's Insulating Fire Brick" and "Armstrong's Cements" are fact-filled booklets about Armstrong's high temperature insulation line. For free copies write to Armstrong Cork Company, Building Materials Division, 1001 Concord Street, Lancaster, Pennsylvania.

Armstrong's

HIGH TEMPERATURE INSULATION

Color now aids the easy and accurate identification of the five types of Armstrong's Brick



Direct-fired oil heating furnace; capacity, 35,000,000 Btu. per hour, heat input to oil

OIL REFINERY FURNACES

Profitable furnace performance is, fundamentally, the result of combining long experience with active engineering study and research.

Built upon this basis, Foster Wheeler furnaces embody all of the progress, knowledge and operating results acquired during 20 years of successfully constructing and installing 1,000 units.

Each design is predicated upon the specific problem of the individual refinery, with full consideration for the flexibility essential for possible future variations in processing and in finished products.

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165 Broadway
New York, N. Y.

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Training Will Accomplish Accident Prevention

C. L. HIGHTOWER
Safety Director, United Gas Pipe Line Company

THE important question in accident prevention is no longer why but how. Today we know that accidents must be controlled in order to insure efficient operations and to conserve the worker's health and maintain his earning ability. These facts have been so firmly established that we do not ask "Why do we need safety." Instead we ask "How are we going to get it."

The best answer to that question is, "Make safety an integral part of operations." Correct job procedure will eliminate lost motion, waste and accidents, giving support to the statement that "safety and efficiency go hand in hand." There may be and usually are many different ways of establishing safety as a part of operations. To start with, physical hazards must be removed or safeguarded by handrails, toe boards, safe walkways, gear and fly-wheel guards, non-slip floor coverings, and the like. Proper lighting, good ventilation and correct sanitary practices are a vital part of the program. In addition, suitable protective equipment such as goggles, hard hats, gas masks, and safety belts must be provided.

Taking care of these physical hazards and providing protective equipment is highly important but the records show that this phase of the program alone will prevent less than 20 percent of the accidents. You ask "what then?" And the answer: training. Training and more training. If man failures account for from 80 to 85 percent of the accidents, the obvious answer is to teach correct work habits.

Safety cannot be dispensed like oil from a tank—by opening and closing a valve. It has to be planted, take root and be cultivated. It must be a part of every operation.

Since accident prevention must be set up as a part of the job it follows that safety training is in effect job training. Where a job is properly planned and the work done right accidents do not occur.

Foreman Logical Safety Teacher

Who is best qualified to do the training job? Others may help but in the final analysis the task rests with the foreman, and properly so. His knowledge of job technique and procedure and the opportunity afforded for observing the man's work habits and studying his characteristics, places the foreman in a position where he can fit the man to a job to which he is physically and temperamentally suited and guide him in developing the technical skill necessary to perform the job efficiently and safely.

Safety training should start with the interview of the applicant. A question here and there as to the applicant's knowledge and interest in safety and his past accident record will serve to impress upon him that his prospective employer considers accident prevention of equal importance with other phases of operation and wants only safe workmen in his employ. At this stage of the game the man is in a receptive mod and any safety lesson that can be impressed is likely to be lasting in its effect.

It is highly important to start the new man right. Proper "breaking in" lays the foundation for future training and development. A sympathetic and understanding attitude on the part of the foreman will go a long way toward relieving tension and fear and help to make the new man feel at ease. A proper introduction to his fellow workers in the crew or gang will also pave the way for his acceptance. These are seemingly unimportant things but it is only necessary to think back to our own experience on a new job in a strange organization to realize what it means to the new man to receive a word of welcome and some indication that he is being accepted as "one of the gang." Contrast such an introduction with the case of the man who is handed a pick and shovel or a wrench and told to "fall in." Which of the two is most likely to develop an interest in his job and his company? Which of the two will be most likely to ask questions if he does not know or understand? The answer is obvious.

Explanation of Hazards

As teachers, one of our biggest mistakes is in assuming that the pupil knows a thing because it has become a simple routine to us by reason of years of practice and experience. In a new environment even the most simple tasks can appear complicated. Because of these conditions the foreman must take time to explain and demonstrate procedures and methods of work. Effective teaching involves three distinct steps. First, tell the man exactly what to do; second, show him, and third, observe his performance to see that he has learned the right way.

Teaching at this point should especially include an explanation of the probable hazards of the work and the precautions to take in order to avoid these dangers. Inspection as to use of protective equipment such as hard hats, goggles, safety belts, and gas masks is also necessary. This instruction should include an explanation of when and how the hazards are encountered and a demonstration of how to use the protective equipment provided.

Old timers on the job can be of

First commercial unit just completed!

ISOMERIZATION

An ample supply of isobutane is essential for the alkylation process of manufacturing high octane aviation gasoline.

Isomerization will produce it.

1. Isobutane for charging to alkylation units is readily produced from normal butane. Nearly all of the normal butane charged can be converted to isobutane with a high conversion per pass.
2. The process is simple, involves inexpensive equipment, operates at moderate temperatures and pressures throughout.
3. Isomerization makes the alkylation process immediately available to the petroleum industry in cases where the ordinary supply of isobutane is insufficient or too expensive.

Under patents of the Shell Development Company.

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invaluable assistance to the foreman in getting the new man started right. If they are asked to help and made to feel that they have a responsibility in this important work of training and job organization these oldtimers usually will respond with enthusiasm. By "sandwiching" in the new men with the old the foreman can secure the help of many well-trained and experienced teachers. It does not relieve him of his responsibility but certainly it lessens the work, all of which would otherwise fall on him.

Training is a continuous process. It is never finished. There are four reasons why this is so:

New employes are continually coming into the organization. They must be trained in the best known and established practices for doing the work.

Employes are being transferred from one job or one department to another. They must be informed on the new work to which they are assigned.

Experienced employes must be reminded. They forget or become lax and develop habits of chance taking.

New processes and new equipment presents new problems. There is nothing permanent but change and we must keep our men informed as to new methods and improved equipment in order to solve the problems that develop with changing conditions.

The most effective method for training in safety or other phases of the job is individual instruction and demonstration on the job. There are other mediums, however, which the foreman can utilize to advantage. Calling on the experienced old timer has already been mentioned. Then there are vocational-training classes, company operating meetings and safety meetings. The workers participation in all these meetings is helpful in safety training as his knowledge of safety increases in proportion to the increase in his knowledge of correct methods and procedures.

A large number of oil and gas companies are sponsoring vocational classes among their employes. Basically these courses are designed to supply the student with information and facts that will enable him to perform his regular job with greater ease and efficiency. Text material used has been developed by the Topical Committee on Vocational Training, Division of Production, American Petroleum Institute, working in cooperation with the various state departments of vocation and industrial training. Information on the organization of classes and a list of text material available may be obtained by writing the Secretary of the Division of Production, American Petroleum Institute, Continental Building, Dallas, Texas.

Job training courses are conducted by some companies but because of the variety of subjects covered and the different training methods employed no effort will be made to cover this phase of training.

Safety meetings are almost universal in the oil and gas industry and in most cases they are held at regularly scheduled intervals, frequently on a monthly basis. The difficulty does not seem to be the lack of an opportunity to meet but rather a problem of finding interesting and instructive subjects to talk about. Since the safety meeting provides a common and also a most effective medium for training it is felt that a discussion of tools and techniques which have proved themselves worthwhile

Visibility

PLUS A PERFECT FIT

WHEN it comes to visibility, you can compare a PYREX Broad Red Line Gauge Glass with any other glass on the market. The results will speak for themselves.

And the accuracy of the gauge glasses you buy has a direct effect on gauge glass maintenance costs. All tubing from which PYREX and CORNING Gauge Glasses are made is machine drawn to uniform accuracy. Thus breakage due to installation strains is reduced to a very minimum.

Add to these important advantages, the relief from danger of breakage caused by sudden temperature shock, resistance to chemical attack and long life, and you have true gauge glass economy. PYREX and CORNING Gauge Glasses are stocked by leading mill and steam supply houses.

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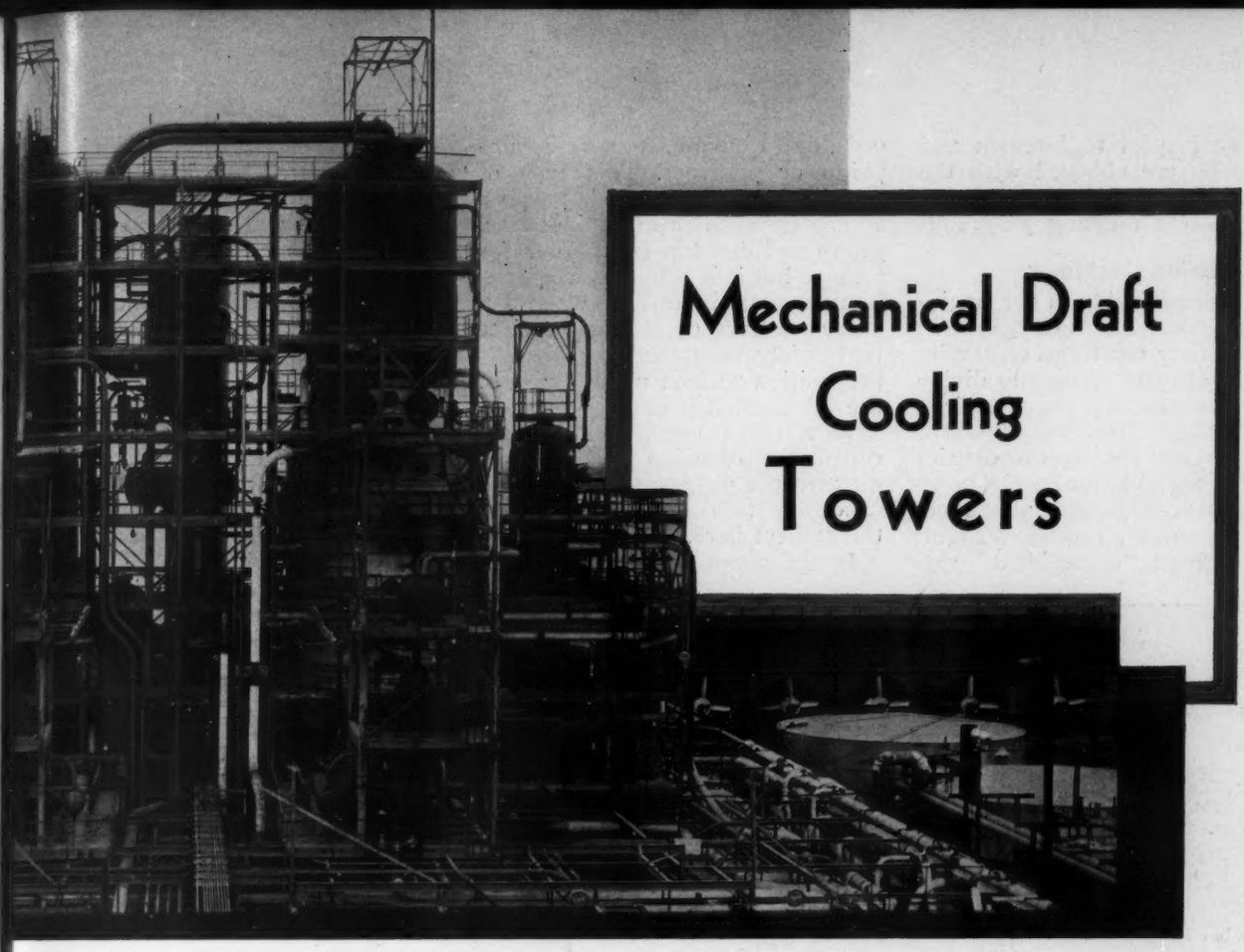
CORNING Glass Works Corning, New York

Pyrex Gauge Glasses



Mechanical Draft Cooling Towers

At the extreme right of the above installation—just beyond the circular tank—may be seen five, four-bladed fans of the twelve-cell cooling tower constructed to operate in connection with this large distillation plant.

In planning an adequate cooling system for new refining units, it is essential that the installation be capable of maintaining full capacity on a year around basis, independent of climatic conditions. Mechanical draft, lowhead cooling towers meet this requirement and provide many advantages from both economic and operating points of view.

They may be built adjacent to massive refining equipment without regard to wind direction or velocity. Many limitations on position are also eliminated through reduced size; water lines are shortened by placing the cooling tower closer to the unit served.

Design engineers, charged with the responsibility of meeting quality and quantity guarantees, have found that lowhead, mechanical draft cooling towers assure full cooling effect and plant output in all seasons of the year due to positive control of performance.

Full-scale research has maintained the advancement of cooling tower practice. Wide range tests have been made of fans, motors, plastics, alloys and fastenings in the Foster Wheeler wind tunnel and experimental towers. Designs, constructions and tower operation have been analyzed, checked and improved to the end that every user of Foster Wheeler mechanical draft cooling towers shall benefit by lower maintenance and operating costs.

● "Integral" cooling tower. The 12-cell, forced draft, lowhead cooling tower illustrated was incorporated in the refinery plot plan at the same time battery unit limits were established for the 30,000 bbl. per day distillation unit; both were erected simultaneously by Foster Wheeler.

● Water . . . 12,000 gallons per minute . . . is pumped to a height of only twenty feet, distributed by gravity, and cooled by air flow from 12 Axial Flow fans, each 12 ft. in diameter. Location of the tower is independent of wind direction, velocity, or proximity of other structures.

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165 Broadway
New York, N. Y.

FOSTER WHEELER

would be helpful to foremen and others who are charged with the responsibility of planning and conducting safety meeting programs.

Safety Meetings

It seems advisable in the beginning to make some distinction in types of safety meetings. Generally speaking, they conveniently divide themselves into three classes. First, there is the "safety rally" where all employes of the plant or district are called together for special occasions to hear important announcements on safety, receive recognition for good "no-accident" records, or to inaugurate a new campaign or program. This type of meeting serves a good purpose where there is need to inspire a group and develop enthusiasm for a cause but it is held less frequently now than in former years because we have come to appreciate that safety must be an every-day proposition and set up as a part of the job itself if it is to get results. Where these special rallies are called the occasion and purpose dictates the program and it is unnecessary to cover this phase of the subject here.

In the second class is the crew or gang safety meeting which is quite popular. These meetings are called on the job by the foreman at a time when work can be conveniently suspended and as often as necessary to accomplish the purpose of assimilating new men, preparing for a new job, discuss some specific hazard or to solve any other safety problem which may arise. These meetings usually do not last long and they are entirely informal. The foreman states the problem, asks for ideas and suggestions, and concludes with a summary of the discussion and the conclusions reached.

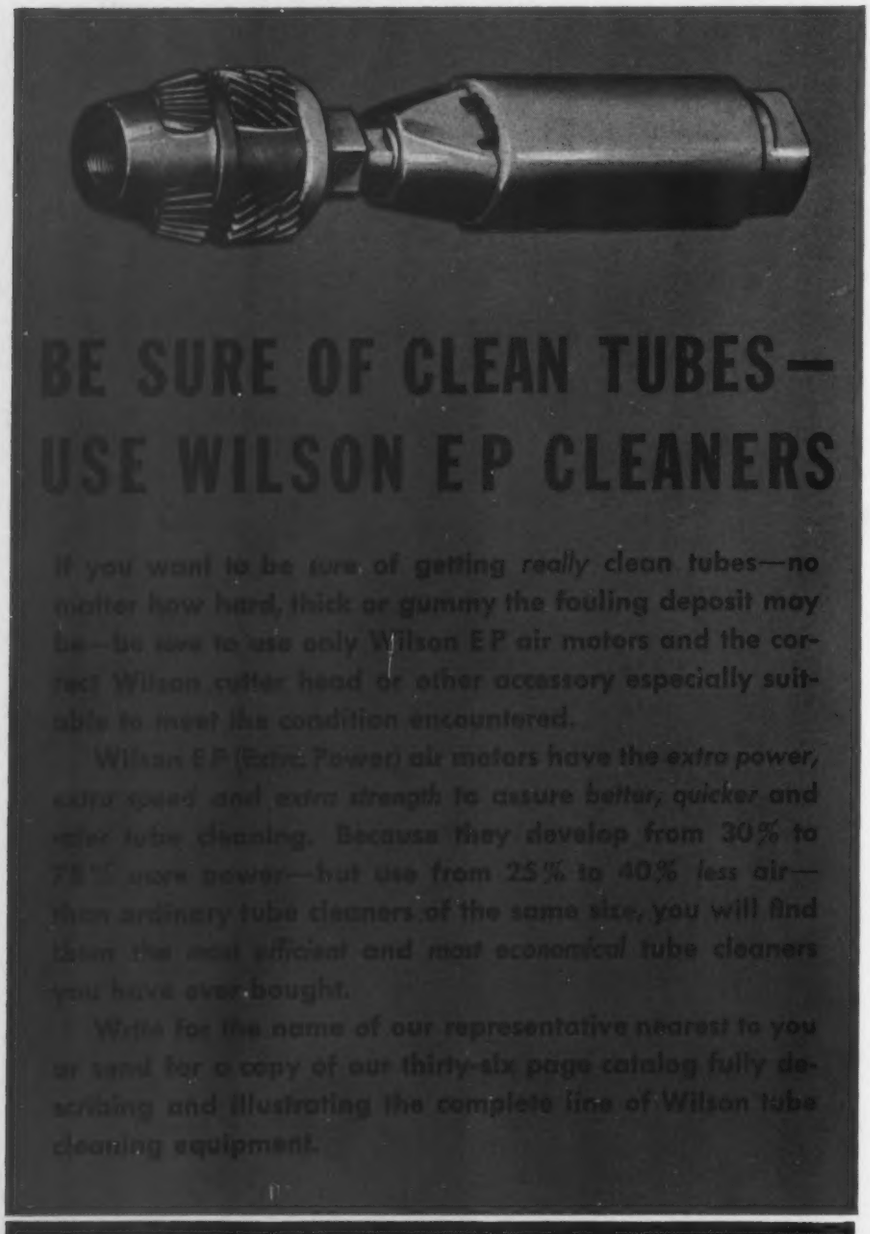
In the third class we have the group meeting where groups of employes in a plant or division of the same occupational classification or in allied classifications meet at regular stated intervals and follow a planned program. This is perhaps the most common type of meeting held in the oil and gas industry and because of the regularity with which the meeting date rolls around it makes the greatest demands on the imagination and ingenuity of the foreman or chairman in order to present a program that will be instructive and at the same time hold the interest of the men.

Proper Groups

The size of the group has a great deal to do with the manner in which the program is conducted. Any group from 12 up to 40 is satisfactory. Where there are less than 12 it is difficult to develop discussion and when there are more than 40 discussion becomes unwieldy.

Of importance to the success of the meeting is seating arrangements, lighting, etc. Comfortable chairs should be provided for everyone. It is expecting too much for a man to stand or remain squatted on the floor and give his undivided attention for 45 minutes or an hour. The room should be ventilated to provide adequate fresh air at a comfortable temperature and suitable lighting is essential if the meeting is held at night.

To a very large extent the success of the group meeting program depends on the chairman. In the first place it is necessary to plan the program in advance; select subjects, appoint speakers, arrange for demonstrations, etc. Also, it is up to him to get discussion started and get as many of the men as possible to participate. The duty of keeping the program moving, steering the discussion away from per-


BE SURE OF CLEAN TUBES—
USE WILSON EP CLEANERS
THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
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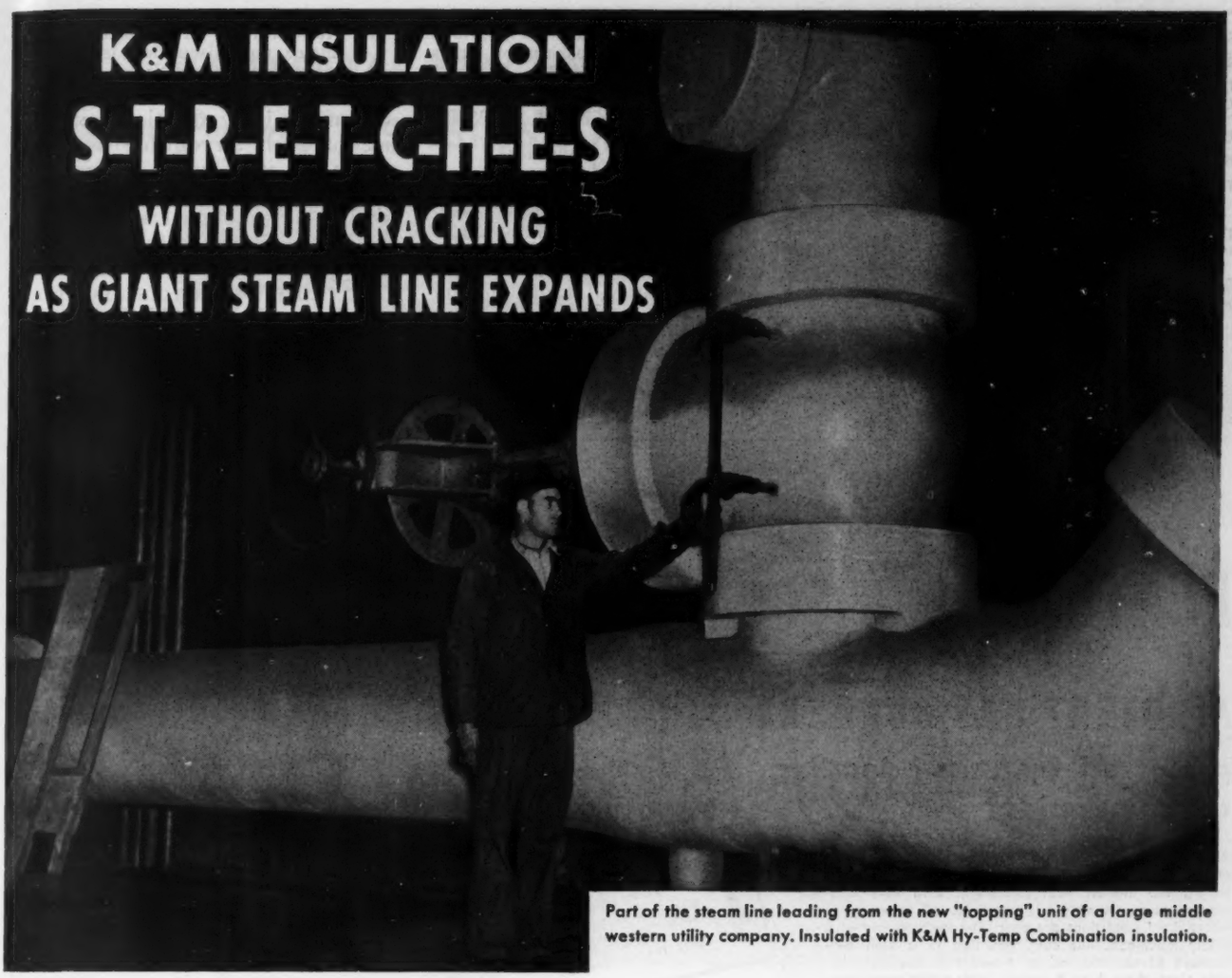
Long Island City, N. Y.



Part of the steam line leading from the new "topping" unit of a large middle western utility company. Insulated with K&M Hy-Temp Combination insulation.

In the new 60,000 KW "topping" unit recently added by a large middle western utility company, the lines from boilers to turbines carry steam at 925°F. and 1300 p.s.i. Incorporating the most modern advances in power plant design, this unit wrings every last B.T.U. from its fuel, and safeguards its full steam energy every inch of the way by means of high efficiency Keasbey & Mattison insulation.

But 650 feet of steam line is bound to expand when heated to 925°F. How was the insulation to be prevented from cracking? Keasbey & Mattison engineers had a ready solution for this problem. They developed a sealed expansion joint that stretches and continues to insulate as the giant pipe expands. Because of it, there is not a single chink in the armor of this K&M installation.

Not only will you find K&M heat insulations outstanding in their efficiency, but you can rely on K&M engineering service to analyze and solve your problems. K&M engineers, working with K&M Distributors strategically located throughout the country for quick service, can point the way to real savings in your plant. Write Dept. 11 for full details.

K&M "Featherweight" 85% Magnesia

KEASBEY & MATTISON
COMPANY, AMBLER, PENNSYLVANIA

sonalities or controversial subjects, and summing up the conclusions reached also falls on the chairman. Since a qualified chairman is so essential to the program, care should be used in selecting the right kind of man for the job.

The chairman, especially if he is new to the job, probably needs an "order of business" to keep him on the right track. Following is a typical outline used for this purpose:

Order of Business

1. Call to order by chairman.
2. Registration of those present or checking of attendance records.
3. Summary of minutes on previous meeting and discussion of items carried over.
4. Introduction of new employes.
5. Reading and discussion of inspection reports.
   (a) Automobile equipment.
   (b) Building and grounds.
   (c) Tools and equipment.
6. Reading and discussion of automobile and personal injury accidents reported.
7. Discussion of first-aid questions listen in Safety Information Bulletin.
8. Discussion of problems and subjects given in Safety Information Bulletin.
9. Talks by visitors or other special features.
10. Appointment of inspection committee and discussion leaders for next month's meeting.

It might be well to sound a note of caution in connection with the use of such an outline as given above. If it is used consistently without variation the meeting is likely to become stereotyped and the proceedings too formal.

The most interesting and instructive radio programs are those which are varied, which challenge our imagination and stimulate our thinking. The same may be said of safety meetings. The difference is that we only turn a dial to tune in such a radio program but we have to work to produce such a safety program.

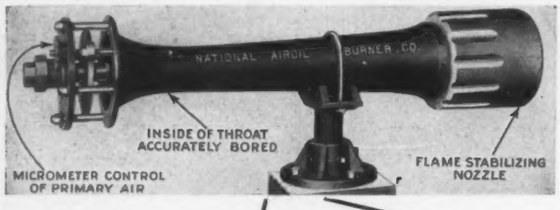
We are told there are three methods of teaching; namely, lecture, conference or discussion, and demonstration. A knowledge of the varied uses to which these methods can be put is helpful in arranging worthwhile safety meetings. The lecture method, so some one has said, is a method whereby notes are transferred from the notebook of the professor to the notebook of the student without passing through the mind of either. This humorous definition does not give proper credit. Although the lecture method is less well suited than the other methods, especially in adult or vocational training, it does serve a useful purpose. In the hands of a competent speaker who is well versed in his subject it can be effective.

Impressive Speakers at Meetings

It is also to be remembered that the safety speech is far different from a platform lecture although the technique used in its delivery may be classed in the same category. The worker who knows his job can get up and tell an impressive story of safety based on his own and the experiences of others that has come to him through the years he has been in the business. Such a story is especially impressive to the practical field man because he cannot help but be impressed with the speaker's knowledge of the subject and his earnestness and sincerity of purpose. Workmen should be encouraged to make these safety talks. Not only do they contribute to the success of the program and influence others but it develops the speaker. In thinking about his subject he learns more about the safety of his job and speaking before a group helps to develop self confidence.

Conference discussions, panels,

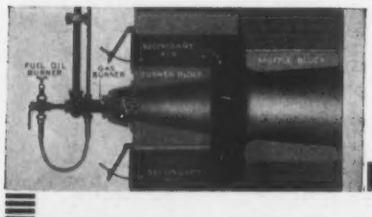
4 FEATURES make AIROVENT GAS BURNERS preferred by many leading oil companies


NATIONAL AIROIL BURNER CO.
INSIDE OF THROAT ACCURATELY BORED
MICROMETER CONTROL OF PRIMARY AIR
FLAME STABILIZING NOZZLE

1. Low "turn-down" without the flame "flashing back." This because of a correctly proportioned flame stabilizing nozzle.
2. Maximum percentage of primary air inspirated by reason of the accurately machined venturi throat.
3. Close adjustment of the primary air-gas ratio easily obtained with our micrometer adjustment on the air shutter. This feature contributes to both high fuel efficiency and ease of regulation.
4. Means for easily and quickly removing or exchanging the gas orifice without disassembling the air shutter.

The Airovent is a venturi inspirating type of gas burner of improved design that produces a non-luminous flame having the highest heat liberation, with only a small amount of excess air. It is suited for all furnaces, even where draft conditions are poor. The ventures are accurately machined, not cast, resulting in a high percentage of air inspiration. Airovent is available in nine sizes, from 1 to 8 inches, with rated capacities up to 11,000 cu. ft. per hr. per burner. One oil company, for example, recently installed 24 of these burners in 1 furnace, producing a heat liberation of 125 million B.T.Us. . . . WRITE US FOR MORE INFORMATION.

ALSO . . . LUMINOUS TYPES OF NATIONAL AIROIL GAS BURNERS, CONCENTRIC CYLINDRICAL TYPE . . . shown below, may be used in a wide variety of registers for forced or natural draft with or without an oil burner in combination. Can be furnished in sizes to take care of burning rates from 200,000 to 7,500,000 B.T.Us. per burner, per hour.

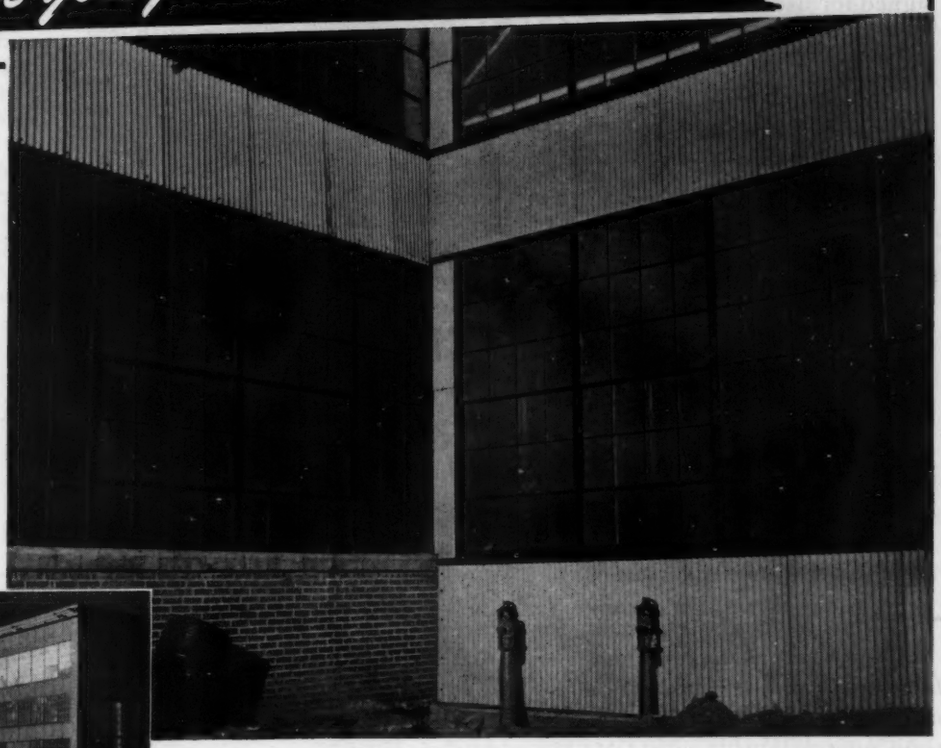


RING TYPE
designed to offer least interference when operating with an oil burner. Both flames burn close to burner, rapidly attaining complete combustion. May be had in sizes from 1 to 12½ million B.T.Us. per hr. per burner.
for full details, write
NATIONAL AIROIL COMPANY, Incorporated
1284 E. Sedgley Avenue • Philadelphia, Pa.

NATIONAL AIROIL BURNER

CATERPILLAR TRACTOR CO. JOINS NEW WALL OF K&M *"Century"* ASBESTOS CORRUGATED TO ONE 4 YEARS OLD

. . . can you pick the new wall?



Unretouched photograph of the junction of two buildings in the Caterpillar Tractor Co. Plant. The siding of both is K&M "Century" Asbestos Corrugated. The four-year-old material on the left is indistinguishable from the new siding on the right-hand building. Material applied by J. W. Bushell Company, Peoria, Ill.

Only a lucky guess could pick the brand new wall of Keasbey & Mattison "Century" Asbestos Corrugated in the photograph above. And the camera doesn't lie, because there is no discernible difference between the old and the new.

After four years' experience with "Century" Corrugated on the sidewalls of one of their buildings, the Caterpillar Tractor Co. of Peoria, Ill., again used this material for a large new addition to their plant. Low upkeep was the reason . . . the same reason which has influenced scores of other large industries to build with "Century" Corrugated.

"Century" Corrugated is known the nation over as a maintenance-free material for sidewalls and roofs alike. It is fire-resisting, weather-resisting, rot-proof and rust-proof. It keeps building maintenance lastingly low, for the passage of time only toughens it. And it is so easily handled and applied that it greatly speeds up construction. FREE: Write Dept. 05 for new, 36-page catalogue.

KEASBEY & MATTISON
COMPANY, AMBLER, PENNSYLVANIA

round tables and quizzes are considered the best devices for arousing interest and securing full participation of all the members in a group meeting. Many companies distribute a Safety Information Bulletin, or similar publication, to foremen and department heads which includes discussion outlines, case problems and questions designed for use in developing round-table or conference discussions. Following is an outline for group discussion on the subject of "defensive driving" which was taken from one company's Safety Information Bulletin. This gives an idea of how such outlines might be prepared on any one of a thousand subjects dealing with safety in the oil and gas industry.

Defensive Driving

Automobile accidents involving company vehicles have shown a 25 percent increase for the first four months of this year as compared to the same period last year, with less than 2 percent increase in vehicle miles. Of the 25 accidents reported through April 25, company drivers were wholly or partially responsible for 11. The following analysis gives the unsafe practices committed by company drivers in these eleven cases:

Unsafe Practice	Accidents
1. Driving too fast for conditions	1
2. Inattention	3
3. Cutting in or crowding	1
4. Passing standing street car	1
5. Failed to signal	1
6. Improper turning	2
7. Following other car too close	2

Although only three of the above accidents caused personal injury, at least one of them could have been extremely serious and in all 25 cases the risk of injury to employes or the public was present. The point is, if we do not exert every effort to control these accidents the law of averages will operate to produce a serious or fatal case.

Defensive driving is a comparatively new term. In effect, it means operating your vehicle in a manner that will enable you to keep out of accidents yourself and at the same time try to safeguard the reckless and indifferent driver. A discussion of the following questions should help us to a better understanding of how to drive defensively:

(a) What is meant by keeping a vehicle under control at all times?
(b) What do we mean by over driving your lights?
(c) What is the proper thing to do when you observe a vehicle approaching on your side of the road?
(d) What precautions should be observed in approaching an intersection even though you are traveling on the right-of-way street?
(e) The driver of another vehicle persists in following your car too closely and will not pass when you slow down. What would you do under these circumstances?
(f) What is the safe thing to do when the driver of the vehicle ahead makes a hand signal?
(g) What should you do if a vehicle starts to pass you on a curve?
(h) Why is it so essential to keep your eyes on the road and your mind on the job of driving at all times?
(i) What precautions can be taken to guard against running down pedestrians at night?
(j) What is the safest procedure to follow when meeting a vehicle with blinding lights?
(k) What extra driving precautions should be exercised when traveling a strange highway?

The case problems on the operations of different departments and the first aid questions shown were taken from the same bulletin:

Problems of the Month

Pipe line—What type of clothing should be worn by a hot dope crew?

Production — Outline a method of cleaning a small tank without the necessity of placing a man in it.

Drilling — Should elevators be removed before attempting to break loose stuck drill pipe?

Gasoline plant and compressor sta-

AVOID DELAY IN FURNACE CONSTRUCTION

Use Refractory Concrete!

...It is available and adaptable

YOU can get the materials for Refractory Concrete and Refractory *Insulating* Concrete *now*—or whenever you want them. Refractory Concrete is made with LUMNITE as the binder for refractory aggregates. LUMNITE is sold by building supply dealers throughout the United States and in Canada. Aggregates *can be easily obtained or prepared in your plant.*

Added to availability is the adaptability of Refractory Concrete and Refractory *Insulating* Concrete. *This also eliminates delay.* Cast-in-place Refractory Concrete is formed to fit the job. Any thickness or shape of wall or arch can be placed without limitation by the size of masonry units, without cutting, and without waiting for special shapes.

High cold-strength speeds up the construction schedule. Refractory Concrete is ready for service in short order, usually before installation of burners and accessories is completed. *You do not have to wait for Refractory Concrete.*

Pre-cast units of Refractory Concrete can be made in your plant, ready for installation as needed. Special shapes, made in any form desired, can be stored or installed the day after molding—without pre-firing.

Let us tell you where you can get LUMNITE and aggregates for Refractory Concrete and Refractory *Insulating* Concrete. Write Atlas LUMNITE Cement Co. (United States Steel Corp. Subsidiary), Dept. R-11, Chrysler Building, New York City.

Keep LUMNITE Castables in Stock—
if you prefer a factory-prepared mixture. Made with LUMNITE and selected aggregates, these castables are ready for use upon mixing with water. With LUMNITE castables you can have Refractory Concrete or Refractory Insulating Concrete in minimum time. LUMNITE Castables are obtainable from refractory manufacturers and distributors in all parts of the United States and Canada.

▶ Specify Castables "Made with LUMNITE" ◀

LUMNITE FOR REFRACTORY CONCRETE

Matchless

U. S. MATCHLESS PACKING
U. S. 899 COMPRESSED ASBESTOS SHEET PACKING
U. S. GPC TANK CAR GASKETS
U. S. PLASMIX PACKING
U. S. PACKING
PLASMIX

FOR YOUR PACKING NEEDS!

For every refinery job — there's a superior U. S. Rubber Packing

WHEN it comes to packing, U.S. Rubber is always right on the job with the right product for each assignment! Put U. S. Packings to work for you . . . your leaks and losses disappear!

More than eighty years' oil field experience and research are behind each U. S. Rubber Packing. That's why oil refiners everywhere have learned to rely on U. S. Packings to do a better job *longer!*

But packing is only one section of a long list of U. S. products that are doing such a top-notch job in the oil industry. From Geophysical Wire to Gasoline Pump Hose you can count on any U. S. Rubber oil field product to give you Service Beyond Price and Specifications.

. . . and also for refinery use —

U. S. MATCHLESS STEAM HOSE
U. S. STILL CLEANING HOSE
U. S. AMAZON TANK CAR HOSE
ROYAL CORD ENDLESS TRANSMISSION BELTS

United States Rubber Company
1230 Sixth Ave. • Rockefeller Center • New York

SERVICE BEYOND PRICE AND SPECIFICATIONS

B-H No. 100 Pipe Covering on nested steam traced lines.

BALDWIN-HILL
No. 100 Pipe Covering

Effective up to 1000° F., it is particularly adaptable to steam traced lines keeping oil running free with no lag in production. B-H No. 100 Pipe Covering is fabricated of high temperature and moisture resistant B-H Black Rockwool, the long fibres being held in place with expanded metal lath on the outside and strips of the same material on the inside. It provides maximum insulating efficiency, meeting the most rigid engineering requirements. Furnished in thicknesses from 1" to 4" to fit pipe sizes ranging from 2" to 30".

BALDWIN-HILL CO., 567 Klagg Ave., TRENTON, N. J.

Yes! I'm interested in B-H No. 100 Pipe Covering.

☐ Send Sample ☐ Send Literature ☐ Send Representative

☐ Send Catalog showing complete line of Heat Insulations

NAME _____ TITLE _____

ADDRESS _____

COMPANY _____

CITY _____ State _____

tion—How often should fire extinguishers be inspected and what constitutes proper inspection?

Home—How can accidents caused by stepping in and out of wet bath tubs be avoided?

First Aid Questions

How should sterile gauze and picric-acid gauze be handled in applying to wounds and burns?

How many types of slings are used in first aid, and what are they called?

What is a tourniquet?

Name some materials that may be used in making an improvised tourniquet?

What materials should not be used in making an improvised tourniquet?

Accident-Prevention Information, a monthly publication distributed by the Department of Accident Prevention, American Petroleum Institute, carries a wealth of information and material suitable for safety meeting discussions. A discussion outline on some timely subject such as good housekeeping, hand and finger protection, and accidents from falls is usually featured. The reports of serious and unusual accidents and studies of special hazards and problems also provide a wealth of subject material.

The A. P. I. has also developed a rather complete list of safe practice manuals dealing with such subjects as "Cleaning Petroleum Storage Tanks," "Handling and Laying Pipe," "Safety in Rotary Drilling Operations" and many others which carry safe practice suggestions for the various jobs performed in each operation. Any one of these manuals will supply enough material for several safety meetings.

Information on A. P. I. Safety Publications may be obtained by writing H. N. Blakeslee, Department of Accident Prevention, American Petroleum Institute, 50 West 50th Street, New York, N. Y.

Safety Subject Material

Publications of the National Safety Council which carry suitable safety-meeting subject material are too numerous to give a complete list. To name a few: National Safety News, Safe Worker, Safe Driver, Speaking for Safety, Public Safety, Safe Practice Pamphlets, and Safety Instruction cards. Additional information on these and other publications available through the council can be obtained by writing National Safety Council, 20 N. Wacker Drive, Chicago, Illinois.

A recent report gives an account of a group safety meeting that had difficulty in adjourning. A production group originated the idea of a

Crudes of the World

For high-grade lubricating oils from almost any type of crude . . . use Furfural Refining

AN OUTSTANDING FEATURE of the Furfural Refining Process is its great flexibility.

Almost any type of crude can be treated to produce lubricating oils of high quality — with a relatively low investment and operating cost.

Today high-grade lubricating oils are in greater demand than ever—for both defense equipment and for regular uses.

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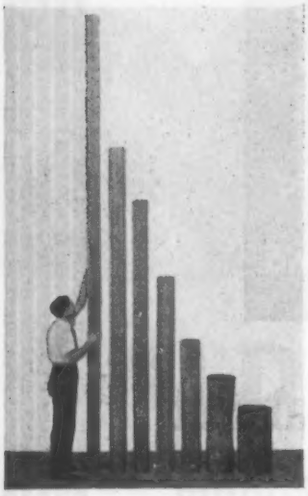
A Subsidiary of The Texas Corporation

26 Journal Square • Jersey City, N. J.

THE DAY THE BOSS YELLED AT MR. HILTON..

"get in touch with Multi-Metal!"



Wire Cloths Stocked in Widths up to 14'

Above: Reactor Screens

Below: Special Drum Type Filters

Yes, some technical angles, on that new process had everybody on edge. So, the boss used his wits and called for specialized experience. Multi-Metal will bring you, too, 30 years' specialized experience in filtering and screening problems, especially those seemingly unsolvable problems! With exceptional coordination of right design and complete plant facilities, we fabricate wire cloth and metal assemblies with unrivalled skill. Always alert to changing conditions and new developments, Multi-Metal will meet your most advanced requirements with applications proved definitely right. In our stock you will find a larger selection of weaves, metals, alloys than anywhere else. For quick and intelligent response to your needs, simple or complex—**"Get In Touch With Multi-Metal!"**

Below: 25' Diameter "Singledisc"—One Homogeneous Fabric

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WIRE CLOTH
FILTER CLOTH
ALL MESHES
ALL METALS

"safety quiz" based on the old fashioned spelling bee. Two leaders chose sides and lined up with their respective groups on either side of the room. The chairman asked the questions and when a man missed he had to sit down. The list of questions was exhausted with some members on both sides remaining on their feet so the game was called on account of time and lack of questions. The competition was fun and everyone present learned something about safety that he did not know before. Here are some of the questions taken from the list:

What shade welding lens should be worn on acetylene cutting and welding work?

Two cars approach an intersection at the same time. Neither street is a "stop" street. Which car has the right-of-way?

What are the symptoms of sunstroke?

What is the explosive range of natural gas?

What three elements are necessary to combustion?

The demonstration or visual method of teaching is effective because approximately 85 percent of the impressions we receive come through the eye. Visual impressions also seem to be retained longer and the ability to gain and hold the audience's attention by demonstrations or other visual methods is proved by the movies and the magicians.

Visual Aids in Teaching Safety

Visual aids in planning safety meeting programs may be classed in two groups; moving pictures and slides, and demonstrations by use of drawings, equipment, and methods. The National Safety Council has developed a series of sound slide films that are suitable for showing before most any industrial group. These can be rented from the council with projection equipment or copies of the films can be purchased at nominal cost. Some companies make their own sound slide films and often times reproduce accidents or near accidents. This is effective because it shows operations, equipment and often men with whom the majority of employes are familiar and also enables concentration on a particular type or kind of accident which is occurring with frequent regularity.

Moving pictures are more expensive and less flexible than the sound slide film. However, there are many good safety films available from the National Safety Council and several of the large life insurance companies. Films, movie or slide, are not advisable as

a steady diet, but as an occasional dish they are invaluable for stimulating interest in the safety program.

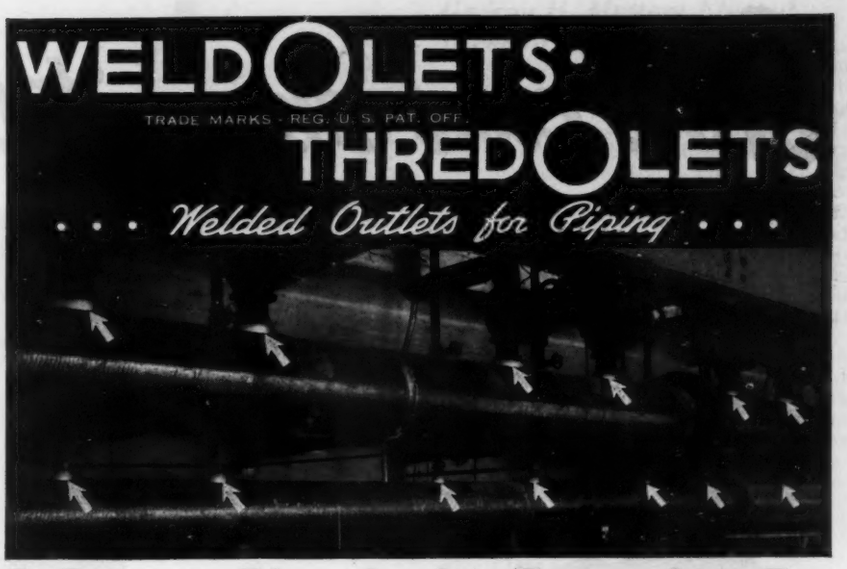
No safety meeting place should be without its black board. It is without equal for illustrating the circumstances of automobile accidents. By showing street and highway intersections and the position and direction of travel of vehicles involved, the cause can be readily pointed out. The black board can also be used to illustrate many types of personal injury accidents. For example, the arrangement of piping, tie-ins and valves which figure in an accident may be effectively illustrated.

Demonstrations by use of actual equipment used on the job is one of the most effective teaching methods. To prove this, attempt to explain to a group how to lubricate a plug valve then bring a plug valve before the group and show how it is done. This example can be multiplied many itmes. It is rather difficult to tell how to adjust and properly fit a pair of goggles or a hose mask face piece, but it is no trick at all to show how it is done.

The most impressive way to teach a man how to lift properly is to show him the position to take and the manner of straightening up with the load. That means demonstrating methods of work and this example too may be multipled many times. To name a few: How to use a fire extinguisher; how to properly fit a wrench on a nut, the proper angle for placing an upright ladder, the correct position to stand in using an axe, the proper clearance between men in using a pick and shovel, and the right way to use a screw driver.

When we consider the many sources on which we may draw for safety-meeting subject material and the many devices which can be utilized to get the group to participate in the program, the task of maintaining interest in safety meetings appears less difficult. It is only a matter of thought, planning and work, and the resulting benefits will more than justify the time and effort required.

Safety meetings have become increasingly important in this period of emergency. In the past there has been adequate incentive to prevent accidents for the sake of the worker and his family and for the good of operations. Today there is another reason equally as important —the defense of our country and our American way of life.



A Branch Pipe Outlet Every 2½ Ft. Without Cutting or Threading the Main Pipe

WeldOlet

IN erecting two 500′ steam lines in a large southern paper mill, it was necessary to provide 400 branch "take-offs"—approximately one every 2½′.

Bonney WeldOlets and ThredOlets were selected because they eliminated all cutting, threading, fitting and forming of the main line and because they made a neater, installation and reduced its total weight.

ThredOlet

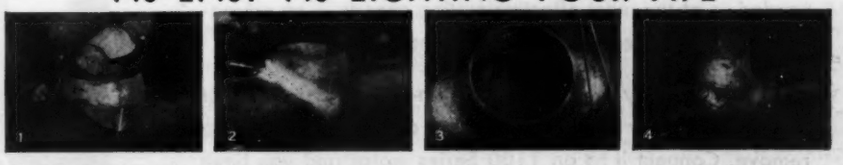
In addition to the tremendous savings in time and labor cost of installation, these fittings provided the additional advantages of lifetime leak-proof joints of full pipe strength and definitely improved flow conditions.

WeldOlets and ThredOlets are recommended for all commonly used pressures and temperatures in every type of piping installation. Any welder of average experience can do a perfect installation job quickly and easily.

Socket-End WeldOlet

For maintenance, renovation or new construction WeldOlets and ThredOlets will give you improved piping efficiency at lower cost. Get full information now about all of their advantages.

AS EASY AS LIGHTING YOUR PIPE



(1)—Select the position of the outlet, rub the fitting over the pipe several times to remove scale, mark center lines and tack the WeldOlet or ThredOlet into position. (2)—The fitting is then welded into place by the electric-arc or oxy-acetylene method. A junction of full pipe strength and a leak-proof joint is the result. (3)—Where the outlet is 2" or larger the button should be removed after the welding operation. On small sizes the fitting is used as a templet and the hole is cut in the main pipe first, either with a hole saw, the torch or by drilling. Inspection of the inside of the joint is possible by using WeldOlets and ThredOlets, allowing the removal of all scale, welding metal, etc. (4)—The branch line is then welded into position. In the event that a ThredOlet is used the branch pipe is threaded and screwed into place.

BONNEY FORGE & TOOL WORKS
Forged Fittings Division - Allentown, Pa.
Forged by the Makers of
The Finest that Money Can Buy
BONNEY TOOLS

You can spin it like a top

This new tube cleaner motor has DOUBLE ball thrust bearings!

AT least 15 percent *more* coke-smashing power than the best previous refinery tube cleaner motors! The double ball thrust bearings in this new Elliott 1100 Series motor eliminate thrust friction caused at one end by the pull of a self-feeding cutter head, and at the other end by the push of the operator shoving the cleaner into heavy coke. You can prove it by spinning the rotor like a top on its bearing. Try this with a conventional motor with sleeve bearing!

The highest torque in this new motor occurs just where it's needed — at the most effective cutting speeds — an advantage whether coke be heavy or thin and hard.

From the many available Lagonda-Liberty types, select the proper cutter head for the kind of coke you want to remove. Connect it to an 1100 Series motor and you have the latest development in tube cleaning and a coke removing combination that gets stills back on stream in record time. Ask for bulletin Y-9 — write or telephone our nearest office.

ELLIOTT COMPANY

LAGONDA-LIBERTY

Tube Cleaner Dept., SPRINGFIELD, OHIO

District Offices in Principal Cities

Y-168

ELLIOTT

(Lagonda type)

DOUBLE BALL-THRUST TUBE CLEANER MOTORS

The Look Box

Bert E. Devere Heads California Refiners

Bert E. Devere, general manager of Pathfinder Petroleum Company, has been elected president of the Independent Refiners Association, Los Angeles. His election followed the resignation of R. E. Hines, Caminol Company. He had been first vice president of the association.

Other changes in association officials included: C. A. Johnson, Socal Oil & Refinery, director; M. M. McCallen, director.

Beeson Heads NGAA Technical Committee

H. H. Beeson, vice president of Sabine Valley Gasoline Company, Shreveport, has been named chairman of the technical committee of the Natural Gasoline Association of America for 1941-1942 working year. He was vice chairman of the committee for the previous year and succeeds C. R. Williams, Continental Oil Company, Ponca City, who is on a special assignment for his company.

In announcing personnel of the committee Ray E. Miller, vice president of Hanlon-Buchanan, Inc., Tulsa, and president of the association said:

"Last year was a heavy one for the men who carry on research for the association for the 1941-1942 period also has important work scheduled. The chief subject is continuation of studies leading to a possible standardization of fractional distillation apparatus and procedure for both gases and liquids. Fifteen company laboratories are cooperating in this project, exchanging identical samples of materials to be analyzed and through correlation of results and gradual changes in methods are gaining reproductability of results."

Other items on the research program include investigation of sample methods for determining sulphur compounds in liquefied petroleum gases; setting up a standard table of volume - correction factors and completing a new hydrometer method for determining the specific gravity of these gases. The committee is working with other national technical groups to set up standard tables of physical constants which may be revised from time to time as newer information is obtained. The committee also has several other projects which will be announced later.

C. E. Wharton, Hanlon-Buchanan, Inc., Gladewater, is vice chairman of the committee. Others members of the committee are: R. C. Alden, Phillips Petroleum Company, Bartlesville; L. A. Boyd, Warren Petroleum Corporation, Tulsa; M. R. Church, Shell Oil Company, Houston; G. P. Crutchfield, Roeser & Pendleton, Inc., Fort Worth; D. B. Dow, Indian Territory Illuminating Oil Company, Bartlesville; F. E. Fisher, Skelly Oil Company, Pawhuska; W. F. Fulton, United Gas Pipe Line Company, Shreveport; R. D. Gibbs, Union Oil Company, Los Angeles; Joe Gershovitz, Parade Gasoline Company, Overton, Texas; F. B. Haverfield, Continental Oil Company, Ponca City; H. J. Hunter, Coltexo Corporation, Monroe; Fred F. Ketchum, Owens, Libbey-Owens Gas Department, Charleston, W. Va.; E. C. LeFevre, Cities Service Oil Company, Bartlesville; E. M. Parkin, Glacier Production Company, Cut Bank; N. K. Rector, Glen Rose Gasoline Company, Tulsa; C. A. Short, Lisbon Gasoline Company, Shreveport; J. L. Thompson, Lone Star Gasoline Company, Dallas; Carl Vickburg, Carter Oil Company, Tulsa, and D. M. Wolfe, Standard Oil Company of California, San Francisco.

W.P.R.A. Ark-La-Tex Office Moved to Tulsa

The office of the Ark-La-Tex Division of Western Petroleum Refiners Association, was moved from Shreveport to Tulsa, July 1. L. C. Grosjean will hereafter have headquarters at Tulsa and his duties will be expanded to wider territory. He will continue to carry on the technical meetings of the Ark-La-Tex area and conduct similar meetings in other areas.

Part of the announcement was:

"The board of directors, after careful consideration, were of the opinion that this procedure would prove more efficient and with these changing times the association would be called upon more by the government to assist in every way possible during this emergency period."

Ryan Resigns Presidency Of National Refining Company

Paul G. Ryan, who suffered several injuries in an airplane accident in Chicago several months ago, has resigned as president of National Refining Company, Cleveland. The prospect of being unable to resume business activity prior to January 1, 1942, prompted him to ask directors to consider his resignation.

CONVENTIONS

SEPT. 8–12	American Chemical Society, Chalfonte-Haddon Hall, Atlantic City.
17–19	National Petroleum Association, Hotel Traymore, Atlantic City.
29–30	National Lubricating Grease Institute, Stevens Hotel, Chicago.
OCT. 6– 8	National Safety Congress, Stevens Hotel, Chicago.
16–18	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Dallas.
31	California Natural Gasoline Association, Los Angeles.
NOV. 3– 7	American Petroleum Institute, St. Francis and Palace Hotels, San Francisco.
3– 5	American Institute of Chemical Engineers, Virginia City, Virginia.

George H. Mettam Elected Director of Jersey Company

George H. Mettam, assistant general manager of refineries of Standard Oil Company of New Jersey, has been elected a director of the company. He has been connected with manufacturing for the concern since 1907, when he went to the Bayway plant for three years. Then he had four years in the field in engineering capacities. His next place was in the Bayonne plant as assistant master mechanic. Promotions resulted in his becoming superintendent of the mechanical and power departments in 1928.

After a brief period at New York headquarters he returned to the Bayonne plant in 1929 as general superintendent. Two years later he was advanced to general manager. In 1933 he became manager of the Bayway plant. He became assistant general manager of refineries in 1940.

Walter G. Whitman On OPM Staff

Dr. Walter G. Whitman, head of the department of chemical engineering, Massachusetts Institute of Technology, has been added to the staff of Dr. Robert E. Wilson, as part time consultant of the petroleum unit, Office of Production Management.

Vaiden Moves Up in Skelly Oil Company

James W. Vaiden, who has been manager of the natural gasoline department of Skelly Oil Company since 1934, has been elected vice president of the company in charge of the newly created manufacturing department. Additional duties will involve supervision of refining plants at El Dorado, Kansas, and Longview, Texas.

Vaiden, a graduate of Alabama Polytechnic Institute, started as a laborer with Skelly Oil Company in 1924. He has held many operating positions in the natural gasoline department. He served two terms as president of the Natural Gasoline Association of America.

Officials Reelected for Tulsa Petroleum Exposition

All officials of International Petroleum Exposition were reelected at the annual meeting of the board of directors at Tulsa, May 20. W. G. Skelly has been president since 1926. Other officials are Frank J. Hinderliter, president of Hinderliter Tool Company, and Alf G. Heggem, president of Oil Well Improvements Company, vice presidents; C. H. Pape, Selby Oil & Gas Company, treasurer. W. M. Bovaird, Bovaird Supply Company and Frank O. Prior, Stanolind Oil & Gas Company, were named as members of the executive committee. H. R. Powers was reelected secretary.

In reporting on the status of the exposition which will be held in Tulsa, May 16 to 23, 1942, William B. Way, general manager, told directors that 271 exhibitors already had contracted for 59.8 percent of the total space.

Dr. Gustav Egloff, director of research for Universal Oil Products Company, Chicago, again was named chairman of the scientific and technical committee. In this capacity he will have charge of the exhibits in the Hall of Science during the 1942 exposition.

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Washington Roundup

SHAPING of the petroleum industry into an effective instrument in the national defense program under Harold L. Ickes, coordinator, has taken the following courses:

There will be five regions, each with four committees, one for refining, one for production, one for marketing, one for transportation.

There was no hint of compulsion in the conference between Ickes and his assistants and perhaps 1000 men of the petroleum industry in Washington, June 19.

There will be no prosecutions for acts done by the industry at the suggestion of the oil coordinator.

Settlement of litigation pending against 21 oil companies and one trade association is indicated.

Legislation is being pressed through Congress for the purpose of permitting construction of pipe lines.

East Coast Oil Shortage

Dislocation of the industry's distribution system through transfer of 50 tankers from Gulf-Atlantic coastwise shipment to British service, which threatens the East Coast with an oil famine and the Gulf Coast with a surplus because of inability to move products, continued a problem of major importance. However, there were various significant developments in this connection that gave increasing assurance that the oil movement disruption might be far less serious than heretofore pictured.

Among the important developments in this connection was news that:

1. Coordinator Ickes was endeavoring to work out arrangements whereby part of the shipments to Britain would originate on the Gulf Coast, whereas the movement heretofore has been altogether from South America.

2. Transfer of three tankers from California-Atlantic service to Gulf-Atlantic service so they could move larger quantities of oil yearly because of the shorter haul.

3. Further indications that load-line limitations on tankers will be increased by 3 percent, which would enable each boat to carry more cargo.

4. Progress made in plans for new pipe-line systems.

These steps indicated that there would be increased movement of petroleum from the Gulf Coast and to the Atlantic seaboard.

Britain to Use Gulf Crude

Heeding urgent pleas of a southwestern Congressional delegation that their oil interests be permitted to participate in the supply of oil to Britain under the Lease-Lend Act, the coordinator June 19 announced American refineries will be given an opportunity to supply at least half of the petroleum products purchased by the government for the use of England.

Representations of the Congressmen and Ickes' decision followed a determination by the Lease-Lend Administration that funds could be used for the purchase of oil, heretofore secured by England almost entirely from Latin American sources. The oil purchases are being made by the Navy Department as agent for the administration, and various oil interests, especially Gulf independents, had represented that they could meet part of the demand and should be permitted to bid on the business.

Placing of British orders with Gulf Coast refiners will not affect the Eastern transportation problem. However, it should serve to prevent the feared piling up of stocks on the Gulf Coast because of the inability to move it to the East Coast due to transfer of tankers from the Gulf-Atlantic service.

The conference in Washington was in large measure a statement of those in government to those in the industry. Ickes let it be known that he intends to keep in touch with the program, although actual details will be under the direction of Ralph K. Savies, assistant coordinator. Ickes said:

"I do not expect to be an ex officio coordinator, for I am vitally concerned with all petroleum problems from the finding of oil to its use by the smallest consumer.

"Highly competent men who have had long, varied and practical experience in dealing with petroleum problems" will be sought, he disclosed, explaining that it was the desire to secure such a man as deputy coordinator which led to the appointment of Davies.

Assuring the industry that the movement would be one of cooperation and not compulsion, Ickes outlined these broad objectives on which his organization would be based.

"The office of the Petroleum Coordinator for National Defense is not established by a specific organic act, and consequently the administrative problem is not one of enforcement. It is not based on the theory of punitive action, quite the contrary; it is anticipated that the solution of most of our problems will be secured by all parties becoming informed and then working out an agreement to which all parties adhere on the basis of their honor and because of an urge to help defend their country.

"Some of these agreements it will not be easy to accept because results cannot always be accomplished without pain and suffering. Yet we must all be prepared at times to sacrifice immediate gains for the future welfare of our country, and it is my hope that the sacrifices, as well as the gains, may be shared equitably by all."

Apparently mindful of the bad taste left in the mouth of the industry by the so-called Madison cases based on a program undertaken at the instigation of the government to dispose of distress stocks of gasoline, Ickes presented as the first speaker, the Solicitor General—Acting Attorney General Francis Biddle—who assured the meeting that nothing they did under the direction of the

petroleum cordinator would be made the subject of action by the Department of Justice.

Biddle told the oil men, incidentally, that "largely as a result of the appointment of the Secretary as Coordinator, I firmly believe that a decree or plan can be worked out satisfactorily to your industry" in the anti-trust case now pending in the District of Columbia court.

The acting attorney general admitted that the industry mistrusted the government, and the government was mistrustful of the industry and declared that this mutual mistrust must be overcome in the interests of national defense.

Assuring that the department would use "discretion" in the enforcement of the anti-trust statutes, he explained, "I do not mean to say that the department would hesitate to enforce the law, but I do mean to say that the circumstances necessarily surrounding the enforcement of any law are changed in a time of grave national emergency."

An agreement has been reached, he disclosed, whereby suggestions to be issued by the coordinator will be referred to the Department of Justice for approval "so there can be no question of fear of the industry running into a snag," while the department itself will consult with the coordinator before taking any action against the industry. As a further safeguard, he said, all recommendations or directions by the coordinator will be reduced to writing, approved by whatever industry committees are concerned, and published in the Official Register.

Changes Are Foreseen

Today's problem is transportation, but that of tomorrow may and probably will be different—production, shortages of vital materials or lack of labor—Davies told the conference.

Because the situation is not static, he explained, it is impossible now to lay down a hard and fast program, but "the stern necessity of accommodating the petroleum resources of the nation to the critical needs of national defense obviously demands government coordination."

"Left to itself," he pointed out, "there is no way by which the industry can effectively organize its resources and facilities so as to deal, quickly and decisively, with the extraordinary problems of the day. No matter how patriotic and unselfish the component interests and groups within the industry, it is clear that as separate and competing units they cannot act cooperatively, independent of government direction."

At the outset of his talk, Davies made it clear that he considered himself dissociated from the industry and an employe of the government, as necessitated by the requirement that he approach his task from the impartial standpoint of government.

Entrusted by the coordinator with the job of telling the industry what would be required of it, Davies frankly admitted that at the present time such a statement was impossible. "The complexity of those problems and the unforeseeable character of future events prevents any such concrete statement today," he said. "But aside from that, the problems that confront us will not be static—they will be constantly changing. They will arise, first, from events outside the industry, and then within the industry—between branches of the industry, and between units within its branches—all as events force an adjustment, first here and then there. In the circumstances, I can do little more than sketch broadly a few of these problems."

Transportation Efforts

Today, he said, the question of transportation is uppermost, and the withdrawal of tankers has forced the necessity for finding alternative methods of movement.

"Some of the more obvious alternatives have already been made wholly or partially effective," he explained. "These include transfer of certain tankers from their customary routes, more complete use of existing pipe lines, and construction of additional pipe-line capacity. The necessary legislation to enable the heavier loading of tank ships is well on its way, and its passage is expected this coming week. The Cole bill clearing the way for pipe-line construction from principal sources of supply to the Atlantic Seaboard has passed the House, and is now before committee in the Senate. Negotiations with railroads and oil companies looking to the utilization of idle tank car capacity, are in progress.

"The extent to which all existing transportation operations can be speeded up and made to function at an absolute maximum, are having attention, and here let me say that I think a very large total contribution can be had from the cumulative effect of a large number of individually small adjustments in a whole series of activities, as loading, dispatching, pumping and inspection. It

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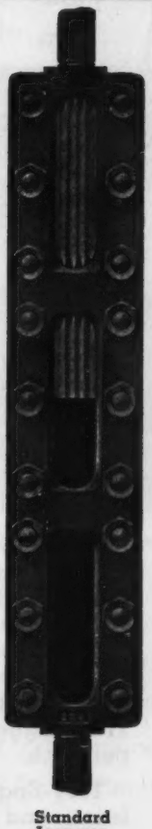

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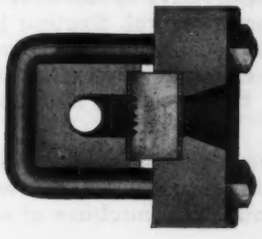

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would seem to me not impossible that as much as 10 percent additional effective service might be had from existing transportation facilities under the stimulus of practical necessity. In normal times, scarcely any operation is conducted with 100 percent efficiency, and an increased productivity of ten percent would seem well within the realm of possibility. And ten percent would be of enormous value at this time.

"Adjustments between producing, refining and marketing regions, and producers, refiners and marketers within such regions, must necessarily be worked out in the light of the facts as they develop in actual, concrete suitations. The difficulties and the complications may be considerable, but our defense needs must be supplied at all times and our civilian needs without restriction if that be physically possible."

Future Problems

Turning to the future, Davies suggested that the problem of "tomorrow" may well be in production, with the necessity to undertake special conservation measures with respect to particular reserves of oil, strategically and geographically so located as to be indispensable to the Navy or essential because of certain peculiar refining charactertistics.

"Or perhaps the problems of tomorrow will arise from shortage of vital supplies and services such as steel, skilled labor, machinery, motor transport equipment," he said. "Already we face the prospect of limitation upon supplies of steel and other metals and materials. It may be that measures will soon be required to avoid the continued competitive drilling of unnecessary wells in proven fields. If shortage of metals and materials prevents competitive drilling, it is obvious that this, in turn, will require further equitable adjustments between operators in order that the fortunate few may not have an unfair advantage. When we speak of drilling restrictions, however, we must recognize that the search for new fields should be the last activity to be so restricted. Unless the discovery rate is maintained, we shall find ourselves not only depleting reserves, but in the unfortunate position of being compelled to overproduce existing fields with all the waste of oil and gas which that entails.

"The industry in general has long supported a policy of conservation and efficient use. Important as conservation has been in the past, it is doubly important today. Our every resource must be made to count; we have no wealth to squander. In this direction, the great reservoir of knowledge and experience of the state conservation authorities will be of great value. The able administration of their respective state conservation laws, directed to the needs of national defense, offers an assurance of good practice and minimum waste in most of the important producing areas. In regions without effective conservation laws, and where good conservation practices are not fully observed, we must seek with you other measures to solve this problem."

Export Control Imposed

In a sweeping order which will permit instantaneous action to cut off oil supplies from any country whose interests are inimical to those of the United States, President Roosevelt June 20 placed all petroleum products under rigid export control. A flat embargo on all shipments from the Eastern seaboard, except to Great Britain, Egypt and the Western Hemisphere, was imposed immediately. The desirability of saving all East Coast supplies because of the oil shortage threat was the reason for this. Restriction of shipments from Gulf Coast or Pacific ports is not contemplated, but by subjecting all petroleum products to export control the machinery for such restrictions is set up and can be put into motion at once if conditions abroad make advisable the stoppage of movements to Japan or Russia.

Earlier, two actions directed toward stopping East Coast exports had been taken by the petroleum coordination office.

Holding that domestic needs took precedence over export trade, Ickes June 16 halted shipment of 240,000 gallons of low-grade lubricating oil to Japan at Philadelphia, and the following day called on the industry to halt further export sales from the East Coast not given approval by his office. A telegram sent 32 oil shippers on the East Coast by Davies stated, "In view of the impending petroleum shortage in the Atlantic Coast area, it is imperative that drainage of stocks from this region be avoided. I suggest therefore that no further sales of petroleum products for offshore shipment be made without prior consideration by this office."

Congressional opposition to the oil coordination effort set up by President Roosevelt's designation of Ickes as

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"czar" of the industry broke out with the introduction by Representative Robert F. Jones and Senator Guy M. Gillette of legislation "to limit the duties which may be performed by certain officers and employees" of the government.

The measure, it was admitted, was specifically directed against Davies, last week named by Ickes as deputy coordinator.

Under the terms of the bill, "no officer or employee of, or adviser to, any department, agency, independent establishment or instrumentality of the federal government shall perform duties in any field in which, or similar to fields in which, such person was previously engaged, if while so engaged and by reason of being so engaged he, or the company of which he was an officer or director at the time, was convicted or pleaded nolo contendere or had a judgment or decree entered against him or it in any case involving the United States."

The bill was an expression of the dissatisfaction which prevails in some quarters over the new coordination program, but there was no indication that administration leaders would permit its serious consideration.

Pipe Lines Studied

Further details of projected pipe line service to the East Coast were ironed out June 26 at a conference between Davies and representatives of 35 oil companies.

The meeting, which also discussed construction of new tankers, went over the various proposals for pipe lines, but it was indicated that a difference of opinion exists with respect to many of the questions considered, which included possible routes, length of time required for construction, type and size of lines, construction costs, engineering problems, sources of supply and operating locations.

Throughout the negotiations it was made clear that the lines were to be built by the industry itself for operation as common carriers, rather than facilities to be built by or with financial aid from the government.

The whole question will be reviewed by Davies, who will submit recommendations to Ickes who, because of the inability of the conferences to come to an agreement, is expected to outline specific suggestions on the size, type and route of the line or lines he feels may be necessary.

The one definite development of the meeting was a decision that additional tanker construction should be undertaken simultaneously with the building of pipe lines and regardless whether such lines are laid.

Railroads vs. Cole Bill

Railroad operators and labor "ganged up" on the Cole bill before a Senate Interstate Commerce subcommittee June 23, declaring proposed southeastern pipe lines had no national defense significance, would lead to an over-supply of transportation facilities at termination of present emergency and thereby throw railroad labor out of work, and also charged enactment of the measure would place the seal of Congressional approval on oil-company ownership of pipe lines which had been condemned by President Roosevelt and was the subject of divorce legislation by Senator Guy M. Gillette of Iowa. Attention also was called to the fact that

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companies involved are charged with monopoly in the pending anti-trust suit. Most of the testimony was directed toward possible injury to railroad operations.

After a second hearing June 27 and a discussion of the situation with Edward B. Swanson, associate director of the petroleum conservation division on June 28, the subcommittee took the measure under consideration and planned to report it to the full committee June 30.

The decision to take quick action resulted from a plea by Coordinator Ickes that delay might result in serious consequences, and an assertion by Swanson that full effects of the diversion of tankers will be felt in the East in the next two or three weeks.

Moving to accommodate its operations to the controls imposed on oil exports by President Roosevelt June 20, the State Department announced it will permit shipment of products which had not previously been subject to restriction, from Atlantic ports to Western Hemisphere points under general license until July 31.

Such products also will be permitted to be shipped under general license to any foreign destination from United States ports other than those on the Atlantic Coast until July 31.

Under the order of June 20, exports of all oil products from the United States were made subject to control and shipments of any product were barred from the Atlantic Coast ports to any destinations except the British Empire, Egypt and the Western Hemisphere.

At the time it was said that no embargoes were contemplated on oil from Gulf or Pacific ports to any destination, but the limitation of such shipments under general license to July 31 will afford an opportunity for review of the situation and a determination of any steps which should be taken to restrict exports from the West Coast in view of the possible new conditions developed by the Nazi attack on Russia, which may involve Japan an a member of the Axis.

A stronger voice for the oil industry in the administration of the defense program by OPM was indicated in plans for reorganization announced by Director General William S. Knudsen and Associate Director General Sidney Hillman.

Appointment of an industry committee representing all branches of the industry and establishment of a special commodity section of the OPM to deal with problems of oil procurement were forecast as likely of announcement in the near future.

Apparently finally stirred by criticism of the cumbersome organization, under which industries with a problem on their hands have had to go from production division to purchasing division to priorities division, and perhaps back again to production, OPM leaders announced a plan for the establishment of industry committees and the setting up of commodity sections in which all questions can be dealt with, whether they apply to production, purchasing or priorities.

The industry committees will act in an advisory capacity, and their operations will be coordinated through a special office to be set up as a clearing house. All defense agencies, as well as the commodity sections, will be enabled to make use of the committees to obtain information and advice bearing upon their respective problems and may have representatives at the meetings between commodity section officials and their advisory committees.

Under this set-up, if an oil committee is appointed and an oil section created, all questions involving oil, whether on priority, production or purchasing problems, would be considered and handled in the oil section, and the chief of that section would forward his recommendations to the appropriate division—purchasing, priorities or production—for action.

So far as oil is concerned, it is probable that many problems presented will be referred to Coordinator Ickes, but it is expected that OPM will continue to keep purchasing and priorities under its control, because of the need for centralized administration of those matters.

The new organization will be patterned along the lines of the War Industries Board of 1918, but efforts will be made to keep it from becoming as complex as did that agency, which had 57 separate commodity sections when it finally folded up.

Price Fixing

Jumping frantically from commodity to commodity in an effort to suppress an apparently expanding inflationary trend, Leon Henderson, chief of OPACS, warned carbon black producers June 25 against further price increases in that commodity.

In a letter to producers, Henderson invited them to come to Washington to talk the situation over and called attention to the position of his office that no price increases should be made unless

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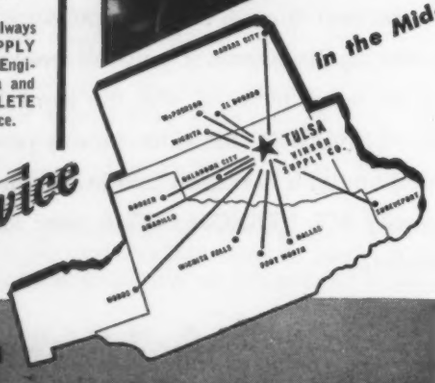

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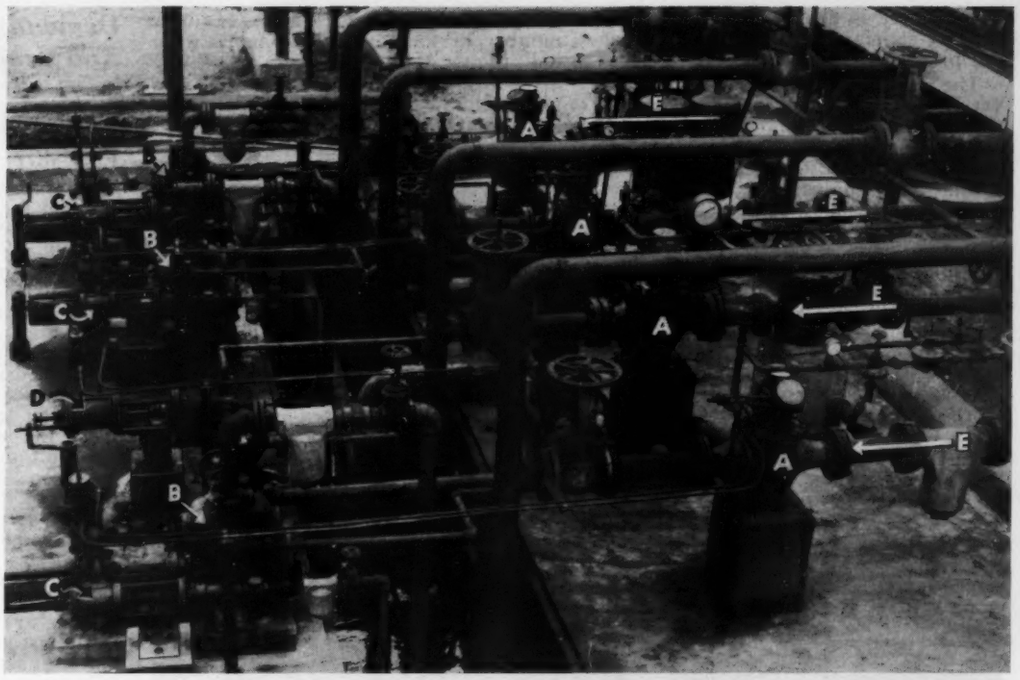

Fig. 1—Automatic blending, dyeing, and inhibiting manifold in large mid-western refinery. Treet-O-Control Meters (A) accurately measure gasoline (E) to be blended. A pilot valve on the Treet-O-Control meter automatically proportions the percentage of Butane or Casing head passing through Vol-U-Meters (B) for adjusting vapor pressure of finished stock. Treet-O-Units (C) proportionally discharge dye to gasoline being blended, while Treet-O-Unit (D) is for proportional addition of gum inhibitor.

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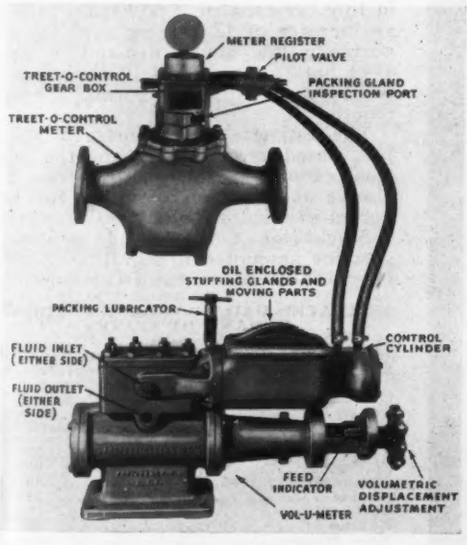

Fig. 2—Typical Treet-O-Control Meter and Vol-U-Meter combination for treating and blending operations.

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the industry is unable to maintain reasonably satisfactory operations at existing prices.

The warning to make no price changes without government approval was actuated by the announcement of a distributor for one of the large carbon black producers of a 12½ percent markup to go into effect July 1.

OPACS officials said that this was the third price increase announced so far this year, as a result of which prices would be almost double those of 1940.

Current stocks of carbon black, it was said, are estimated to be equal to about three months' supplies. Demand in the domestic market has been running well ahead of a year ago, although exports have been affected adversely by the war.

As the OPACS attempted to deal with threats of price increases in a number of unrelated lines, there were indications that President Roosevelt soon would ask Congress for legislation giving the government authority to impose a mandatory price control.

Appearing before the House Appropriations Committee at hearings on the bill carrying funds for his agency, Henderson admitted that the situation may soon get out of hand, as the pressure of deficiencies in shipping facilities, scarcities in imported commodities and demands of labor for wage increases spread throughout industry.

It was made plain that the Administration does not want to get into the price-fixing field until it has to, but it was not denied that the inflationary trend is spreading rapidly.

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Demand for Motor Fuel And Crude Oil, July, 1941

The daily average supply of domestic crude oil estimated by the Bureau of Mines, United States Department of the Interior, to meet the market demand in July, 1941, is 3,847,100 barrels. This is 17,100 barrels higher than the estimated demand for June and is 6 percent above the actual demand for July, 1940.

Daily average crude-oil production and runs to stills during the five weeks May 10 to June 7 were 3,790,000 and 3,813,000 barrels, respectively. During this period domestic stocks declined an average of 123,000 barrels daily, indicating a demand of 3,913,000 barrels.

The effects of readjustments in transportation and consumption resulting from the withdrawal of tankers from the Gulf to East Coast movement are still too indefinite to be accurately measured. The bureau's forecast for July reflects the trends of the latest available data and indicates at least temporary curtailment of Gulf Coast markets, and an increase in the relative production of the refinery districts further to the north and east. Increases in the estimated demand for Oklahoma and Illinois crudes are based on probable withdrawals from storage. The ultimate change in the market demand for crude from the states supplying the Gulf and East Coast areas will depend on the speed with which transportation readjustments become effective and also upon the extent to which the diverted tankers may move products directly from the Gulf Coast for British use or for increasing naval requirements.

The net effect of the transportation situation on the bureau's forecast of demand for July has been to reduce an anticipated substantial increase in the estimated total demand for crude and refined products and to cause greater readjustments among sources of supply than were indicated by previous trends.

The domestic demand for motor fuel in July is estimated at 60,300,000 barrels, an increase of 12 percent over the abnormally low actual demand in July, 1940, but an increase of 10 percent over the bureau's estimated normal for that month.

The estimate for exports of motor fuel, based upon forecasts by the principal exporters, is 2,000,000 barrels, exclusive of re-exports of motor fuel imported in bond.

Stocks of finished and unfinished gasoline amounted to 95,931,000 barrels on April 30. Statistics of the American

ESTIMATED DAILY AVERAGE CRUDE-OIL DEMAND BY STATES
(Barrels)
(As no changes in crude-oil stocks are involved in these estimates, they represent demand rather than production)

State	Forecast July, 1941
Texas	1,324,000
California	624,800
Oklahoma	498,500
Illinois	384,800
Louisiana	304,000
Kansas	225,300
New Mexico	108,600
Wyoming	88,400
Arkansas	77,000
Pennsylvania	49,300
Michigan	37,200
Indiana	22,200
Mississippi	21,000
Montana	19,900
Kentucky	16,200
New York	15,000
West Virginia	10,800
Ohio	10,800
Colorado	5,100
Nebraska	4,200
	3,847,100

Petroleum Institute indicate that gasoline inventories declined about 2,600,000 barrels during May, which would leave approximately 93,300,000 barrels in storage as of May 31. This is 7,600,000 barrels less than the stocks on May 31, 1940. The bureau estimates a decrease of 3,800,000 barrels during July.

Benzol production and direct sales of natural gasoline are estimated as 1,800,000 barrels, making an indicated refinery production of 56,700,000 barrels, distributed among the various refining districts as follows (thousands of barrels): East Coast, 7050; Applachian, 2200; Indiana-Illinois, 12,550; Oklahoma, 2890; Kansas-Missouri, 3250; Inland Texas, 3580; Texas Gulf Coast, 13,800; Louisiana Gulf Coast, 1640; Inland Louisiana-Arkansas, 1060; Rocky Mountain, 1540; California, 7140.

Natural gasoline to be blended at refineries is estimated as 5.8 percent of the total refinery production, or 3,280,000 barrels. The yield of straight-run and cracked gasoline is estimated as 44.98 percent, which applied to the production of 53,420,000 barrels gives crude runs of 118,760,000 barrels, or 3,831,000 daily.

The estimate for foreign crude runs to stills is 3,900,000 barrels.

The estimate for crude-oil exports is 2,900,000 barrels, compared with actual exports of 5,607,000 in July, 1940.

Crude oil to be used as fuel and losses is estimated as 1,500,000 barrels.

The estimated demand for domestic crude oil is 119,260,000 barrels, or 3,847,100 daily.

A.S.T.M. Officials Elected at Chicago

G. E. F. Luncell, chief of the chemistry division, National Bureau of Standards, was elected president of the American Society for Testing Materials at the annual meeting in Chicago, June 24. Dean Harvey, Westinghouse Electric & Manufacturing Company, was chosen vice president.

Members of the executive committee are: Arthur W. Carpenter, B. F. Goodrich Company; T. A. Fitch, Bureau of Standards; Carl D. Hocker, Bell Telephone Laboratories; J. L. Miner, Atlas Lumnite Company; E. W. Upham, Chrysler Corporation.

Committees Named For Annual ACS Meeting

Seymour W. Ferris, chief chemist of The Atlantic Refining Company, Philadelphia, has been appointed chairman of a general committee to direct arrangements for the meeting of the American Chemical Society, Atlantic City, September 8 to 12.

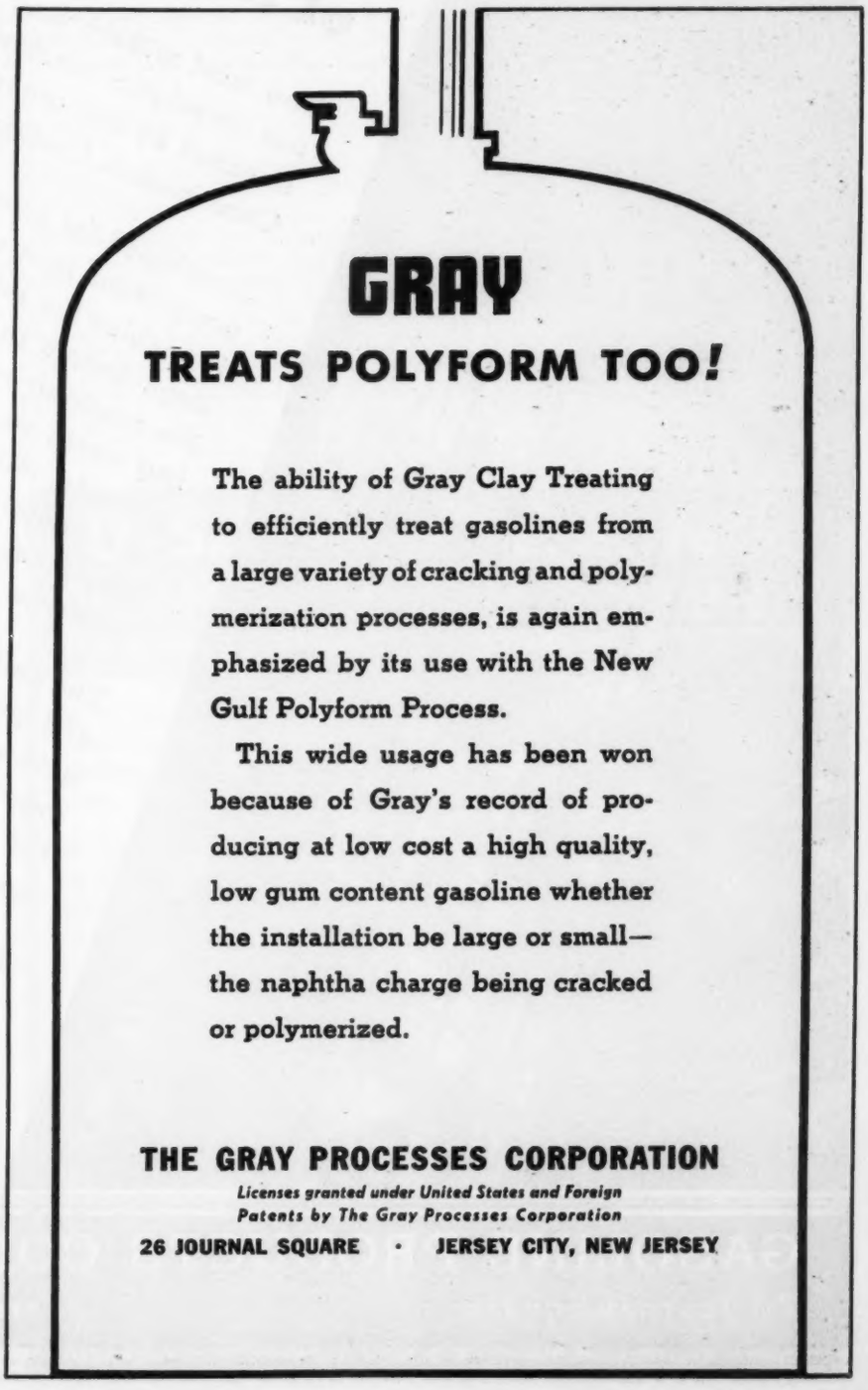
More than 5000 chemists, chemical engineers, industrialists, educators, and representatives of allied fields including state and federal services will participate in the events.

Seventy-eight sessions, at which research in practically every sphere of pure and applied chemistry will be reported, are scheduled by the eighteen divisions of the society. Seventeen special symposia will deal with a wide range of current scientific investigation. Fuels, food, petroleum, phosphates, rubber, medicinals, unit processes in industry, and biological problems related to national defense are among the subjects to be discussed.

An executive convention committee has been named as follows: Lyle L. Jenne of the Philadelphia Bureau of Water; J. Bennett Hill, manager of the development division of Sun Oil Company, Philadelphia; Newcomb K. Chaney, director of research of United Gas Improvement Company, Philadelphia; Professor H. J. M. Creighton of Swarthmore College; Professor Hiram S. Lukens, director of the department of chemistry and chemical engineering of the University of Pennsylvania, and William Stericker, development chemist of the Philadelphia Quartz Company.

Chairmen of subcommittees are: Dr. Alexander G. Keller, Jr., of the Graduate Hospital of the University of Pennsylvania; Dr. Johannes H. Bruun, manager of the Experimental Division of Sun Oil Company, Norwood, Pennsylvania; Loren C. Hurd of Charles Lennig & Company, Philadelphia; Dr. Horace M. Weir, manager of the Chemical Engineering Division of United Engineers & Constructors, Inc.; Professors Ralph Connor and Harry A. Alsentzer, Jr., of the University of Pennsylvania; Mrs. Horace M. Weir.

P. Edward Rollhaus of Ugite Sales Corporation, Philadelphia; Professor J. Howard Graham, head of the departments of organic chemistry and physics at Temple University Pharmacy School; Joseph W. E. Harrisson of LaWall & Harrisson, Philadelphia consulting chemists; Steward S. Kurtz, Jr., of Sun Oil Company; Professor Edward L. Haenisch of Villanova College; Dr. Mildred M. Hicks-Bruun, research chemist of Sun Oil Company.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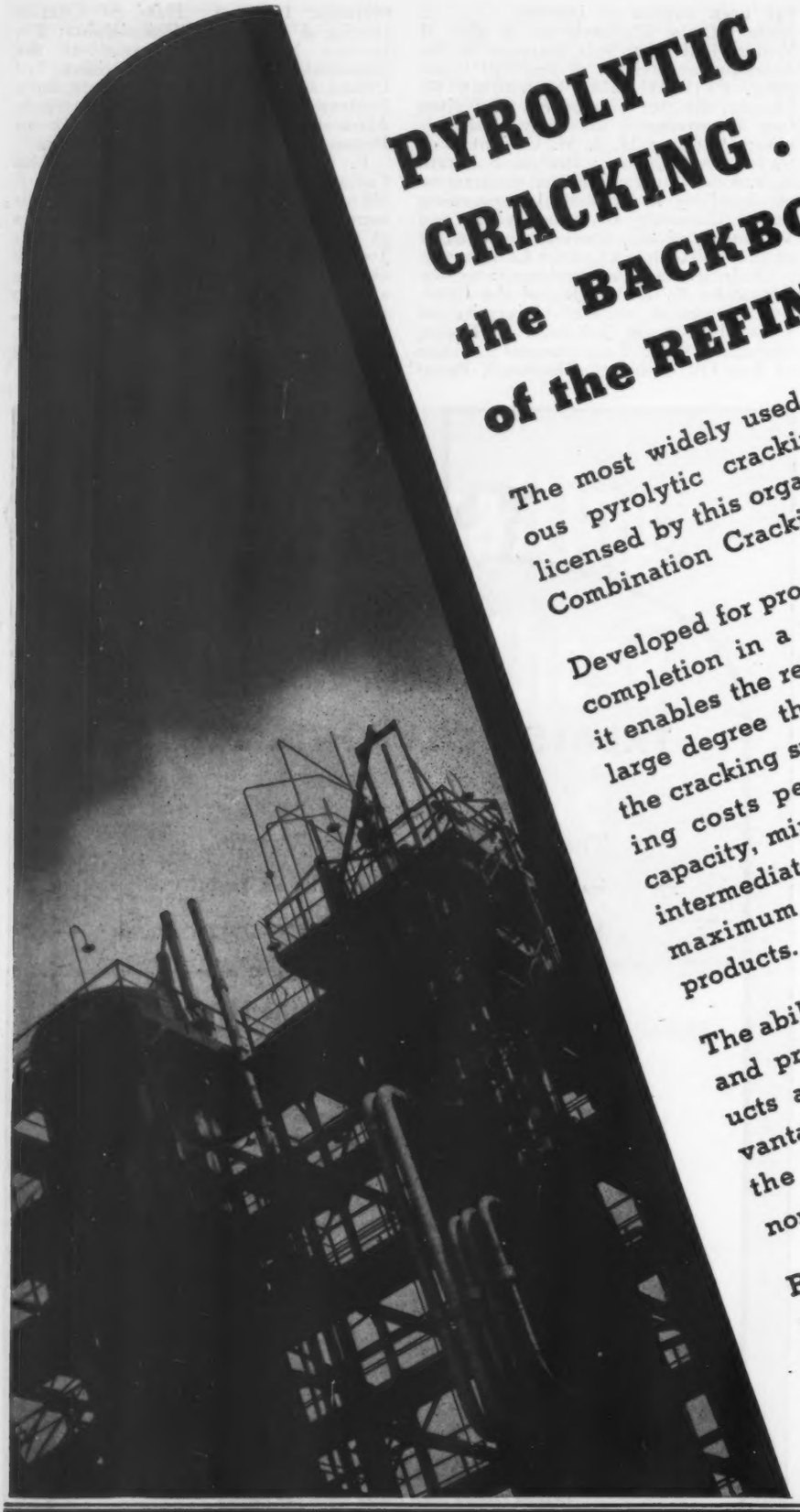

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original artucles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Temperature Coefficient of Density and Refractive Index for Hydrocarbons in the Liquid State, M. R. LIPKIN AND S. S. KURTZ, JR., *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 291-5.

Using the equation

$$d_{t/4} = d_{20/4} + \alpha(t - 20) + \beta(t - 20)^2$$

a single surve of α vs. molecular weight and a single curve of β vs. molecular weight have been found applicable to all types of hydrocarbons with very few exceptions. From these curves the temperature coefficient of density of a liquid hydrocarbon at atmospheric pressure can be predicted from the molecular weight within $\pm$ 0.00002 gram per cc. per 1° C. The only definite exceptions to this relationship are benzene, pentaethylbenzene, and hexaproplybenzene, which show coefficients 0.00010 gram per cc. per 1° C. higher than the predicted values. The curves are also applicable to hydrocarbon mixtures. This relationship is more general than any previously published for predicting the temperature coefficient of density. The corresponding relationship between compressibility and molecular weight is under investigation. Since Ward and Kurtz have shown that for hydrocarbons

$$\Delta n = 0.60 \Delta d$$

an accurate method of calculating density change also provides a satisfactory method for the calculation of change in refractive index with temperature.

Liquid-Vapor Equilibrium Relations in Binary Systems, W. B. KAY, *Ind. & Eng. Chem.* **33** (1941) pp. 590-4.

The P-V-T-x relations at the liquid- and vapor-phase boundaries in the n-butane-n-heptane system were developed from measurements on a series of mixtures varying in composition from pure n-butane to pure n-heptane. T-x diagrams for the coexisting liquid and vapor at constant pressure were constructed, from which data were obtained for calculating the phase-equilibrium constants. Information on the effect of the physical properties of the mixture on the phase-equilibrium constants is given by a comparison of the constants for n-butane dissolved in ethane and in n-heptane, and of those for n-heptane dissolved in ethane and in n-butane. The data are presented in some detail in tabular and graphical form.

Thermal Properties of Pentane, P. R. KONZ AND G. G. BROWN, *Ind. & Eng. Chem.* **33** (1941) pp. 617-23.

Accurate information on the thermal properties of hydrocarbons is becoming more important with the increasing use of high temperature and pressure. The compound n-pentane was selected for study because it is representative of those used in industrial practice and could be investigated thoroughly in the region of the critical point and at high reduced temperatures and pressures. The effect of pressure and temperature on the enthalpy of pentane was determined by means of the Joule-Thomson expansion from pressures up to 3000 pounds per square inch and temperatures up to the point of decomposition of the substance, with particular care in the critical region. The data secured are presented in considerable detail in tabular and graphical form. A pressure-temperature plot showing lines of constant enthalpy is included.

Free Energies of Formation of Gaseous Hydrocarbons and Related Substances, C. M. THACKER, H. O. FOLKINS, AND E. L. MILLER, *Ind. & Eng. Chem.* **33** (1941) pp. 584-90.

Standard free energies of formation have been calculated for 77 hydrocarbons and 8 inorganic compounds in the gaseous state at 100° C. intervals from 298.1° to 1200° K. The tables include values for the normal paraffins (methane to n-decane), the 1-olefins (ethylene to 1-decane), various branched-chain saturates and unsaturates of 4 to 8 carbon atoms, and the inorganic compounds carbon monoxide, carbon dioxide, water, ammonia, carbon disulfide, hydrogen sulfide, sulfur dioxide, and sulfur trioxide. Distinction is made between the more accurate values for straight-chain hydrocarbons and those for their branched-chain isomers. The methods of calculation used are given. The data are presented in tabular form.

Determination of Heat of Combustion of Gasolines, W. H. JONES AND C. E. STARR, JR., *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 287-290.

Determination of the heat of combustion of gasolines is becoming increasingly important and is included in certain aviation gasoline specifications. A better procedure than that ordinarily employed by petroleum testing laboratories for heavier fuels, in

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which losses of the more volatile components of the gasolines such as butanes and pentanes are avoided, is required. A procedure was developed whereby six to eight determinations could be made per day on low boiling aviation gasolines with an accuracy of 0.2 percent. A calorimeter of the adiabatic type is employed. The apparatus is described in some detail. Typical results are given. A correlation was developed between heat of combustion and percent of hydrogen. Aromatics, naphthenes, and paraffins follow an almost straight line relationship. The tabulation of the heats of combustion of clear hydrocarbons boiling in the gasoline range is given, including paraffins, naphthenes, aromatics, and olefins. A bibliography of 31 references on the general subject is given.

Solubility of Methane in n-Hexane, E. P. SCHOCH, A. E. HOFFMANN AND F. D. MAYFIELD, *Ind. & Eng. Chem.* **33** (1941) pp. 688-91.

An apparatus and experimental method for high-pressure determination of P-V-T-X relations of two-component hydrocarbon systems have been previously described by the authors. The solubilities of methane in n-hexane corresponding to pressures up to the critical and at temperatures of 100.27°, 160° and 220° F. are reported in the form of bubble-point data. Specific volumes of the liquid phases, together with their compressibilities up to 6000 pounds per square inch, are given. The data are presented in considerable detail in tabular and graphical form. The effect of structure of the solvent on the solubility of methane is illustrated by curves showing the solubility in hexane, cyclohexane, and benzene. Methane is most soluble in the paraffinic hydrocarbons, and least soluble in the aromatics.

Nomographs for Thermal Conductivities of Gases and Vapors, D. S. DAVIS, *Ind. & Eng. Chem.* **33** (1941) pp. 675-8.

In connection with the design of heat transfer equipment there is need for a convenient and rapid means of estimating the thermal conductivities of gases and vapors at various temperature levels. Gases and vapors fall into three classes, depending upon the manner of the variation of K with temperature. Three nomographs are given; one for methane-ammonia-carbon-dioxide and nitrous oxide; the second for oxygen, hydrogen, air, nitric oxide and carbon monoxide; and the third for organic vapors, such as the hydrocarbons, alcohols, and esters.

Natural Gas Hydrates, W. I. WILCOX, D. B. CARSON, AND D. L. KATZ, *Ind. & Eng. Chem.* **33** (1941) pp. 662-5.

Natural gases under pressure unite with water to form crystalline hydrates at temperatures considerably above 32° F. As a result of the accumulation of liquid water in a natural gas pipe line and under favorable conditions of pressure and temperature the line may become plugged with a solid phase. The investigators give data on the temperatures and pressures, up to 4000 pounds per square inch, at which three natural gases form hydrates. The phase data on hydrates of pure hydrocarbons were enlarged by the equilibrium temperatures and pressures for the hydrate formation from compressed liquid propane. The concept was introduced of handling vapor-solid equilibria in the same manner as the vapor-liquid equilibria data have been used to predict the phase relations of fluid hydrocarbon systems. The data are presented in some detail in tabular and graphical form.

Ring Method for the Determination of Interfacial Tension, H. H. ZUIDEMA AND G. W. WATERS, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 312-13.

Interfacial tension may be of importance in the study of small changes in concentration of impurities during the refining of petroleum and in studies of the deterioration of hydrocarbon oil, either in accelerated stability tests or in actual service. Values obtained by the ring method may be in error by as much as 30 percent. It was found that for a given range the correction factor is determined by a mathematical relationship that is presented. This relationship permits extrapolation of the data with reasonable certainty, and to the degree required for the application of the ring method to the interfacial tension of hydrocarbon-water interfaces. Nine oils were studied. The properties of these oils are given. The data show good agreement between the results of the capillary method and the corrected results obtained by the ring method.

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Liquefies at -34.6°C. at atmospheric pressure. Not over 1.4 lbs. moisture per ton. Total residue not over 15 grams per 100 lbs.

Chemical Compositions And Reactions

Hexabenzylethane, G. A. HILL, W. C. NELSON, R. L. DUNNELL AND L. S. MOODY, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1367-8.

The investigation was undertaken to prepare the long-sought hydrocarbon, 2,2,3,3-tetrabenzyl-1,6-diphenylbutane, i.e., hexabenzylethane. Thibenzylmethyl bromide was prepared and converted to hexabenzylethane which in turn was characterized by nitration to a hexanitroderivative. The best yield of hexabenzylethane resulted when tribenzylmethyl bromide in benzene was acted upon by zinc.

The Nitrogen Compounds in Petroleum Distillates. XXI. Isolation and Synthesis of 2,3,4-Trimethyl-8-i-propylquinoline, L. M. SCHENCK AND J. R. BAILEY, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1364-5.

The isolation of 2,3,4-trimethyl-8-i-propylquinoline from California petroleum is reported. The structure of the compound was established through chromic acid oxidation to the known 2,3,4-trimethylquinoline-8-corboxylic acid and was confirmed by synthesis from methylacetylacetone and o-cumidine.

The Nitrogen Compounds in Petroleum Distillates. XXII. Isolation and Synthesis of 2,3-Dimethyl-4,8-diethylquinoline (I) and 2,3-Dimethyl-4-ethyl-8-n-propylquinoline (II), L. M. SCHENCK AND J. R. BAILEY, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1365-7.

The isolation of a new quinoline homolog, 2,3-dimethyl-4,8-diethylquinoline, from petroleum is reported. The use of sulfur dioxide in segregating a second new nitrogen base, 2,3-dimethyl-4-ethyl-8-n-propylquinoline, is also described. The structure of these hitherto unknown petroleum bases has been established through degradation and confirmed by synthesis.

Atmospheric Oxidation of 6-Dodecyne, M. J. MURRAY AND F. F. CLEVELAND, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1363-4.

During an investigation of the Raman spectra of disubstituted acetylenes, it was

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found that 6-dodecyne upon standing in contact with air is oxidized to give 6-dodecynone-5. Preliminary experiments indicate that other disubstituted acetylenes react in a similar manner.

Polymerization of Olefins. IV. The Nonenes from the Dehydration and Copolymerization of t-Butyl and t-Amyl Alcohols, F. C. WHITMORE AND L. W. MIXON, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1460-2.

The investigation was undertaken to throw additional light on the mechanism of the polymerization of olefins. Two tertiary alcohols were chosen because the related olefins polymerize with extraordinary ease in the presence of acid catalysts. The dehydration of an equimolar mixture of t-amyl and t-butyl alcohols with 65% sulfuric acid yields 17% nonenes. The mixture could not be separated by repeated fractionation. Ozonolysis of the nonene mixture and identification of the ozonolysis products indicates the percentage composition of the nonene mixture to be 2,3,4,4-tetramethyl-1-pentene, 50%; 2,3,4,4-trimethyl-2-pentene, 10%; 3,5,5-trimethyl-2-hexene, 23%; 3,5,5-trimethyl-3-hexene, 5%, and 2,4,4-trimethyl-2-hexene, 10%. The significance of the results is considered in terms of the mechanism of olefin polymerization.

III. Two-Component Gel Catalysts Containing Chromium Oxide for the Aromatization of n-Heptane, H. FEHRER AND H. S. TAYLOR, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1385-6.

Several two-component gel catalysts containing chromium oxide were studied for the dehydrogenation-cyclization of heptane. Incorporation of the hydrogenating oxide catalysts, zinc, manganese and molybdenum oxides produces catalysts that tend to favor low olefin content with a given production or aromatics. Incorporation of silica does not materially increase gel stability but produces greater availability of chromium oxide surface. Incorporation of zirconia and stannic oxide as promoters produces catalysts superior to standard gel due to the slower rate of poisoning. The catalysts are somewhat sensitive to the revivification procedure and lose activity. Zirconia has itself dehydrogenating-cyclizing activity toward paraffins at 475° C.

IV. The Mechanism of Reaction and of Poisoning in the Dehydroaromatization of n-Heptane, H. S. TAYLOR AND H. FEHRER, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1387-92.

Initial cyclization of heptylene-1 on chromium oxide catalysts is more rapid than that of heptane. The catalysts poison more rapidly. Heptylene-1 in 15% concentration in heptane reduces the over-all conversion to toluene. Methylcyclohexane is more rapidly dehydrogenated to toluene than heptane or heptylene-1 and does not poison the catalyst. Ethylene strongly poisons chromium oxide catalysts by deposition of carbonaceous material on the surface, removable only by oxidation. Simultaneous presence of hydrogen may eliminate the poisoning action of ethylene. Analysis of the data secured indicates that dehydrogenation of the heptane is inhibited by heptylene and is the slow process in the whole sequence. Aromatization is more sensitive to poisons than paraffin dehydrogenation.

Catalytic Dehydrogenation of Hydroaromatic Compounds with Benzene, H. ADKINS, L. M. RICHARDS AND J. W. DAVIS, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1320-5.

A catalytic process is described in which hydroaromatic compounds containing a completely or partially saturated benzene, naphthalene, or phenanthrene nucleus are dehydrogenated to the corresponding aromatic compounds in good yields. Twenty-eight representative compounds including hydrocarbons, alcohols, ketones and ethers, have been dehydrogenated and the results are summarized in tables. The process consists in heating the hydroaromatic compound at 300 to 350° C. in the liquid phase under nitrogen with benzene in the presence of a nickel or platinum catalyst. Under these conditions benzene takes the hydrogen from the hydroaromatic compound and thus serves as a hydrogen acceptor or oxidizing agent. Various methods have been described for preparing nickel catalysts. It has been found that nickel on chromium oxide is perhaps the most active catalyst for the dehydrogenation of these saturated hydrocarbons that are particularly resistant to reaction. Nickel on alumina or nickel on kieselguhr, however, are better catalysts for the dehydrogenation of substituted cyclohexanols because they show less tendency to induce condensations. Platinum in some instances was active at a lower temperature than nickel, but it was not active for the dehydrogenation of certain compounds. Nickel gave

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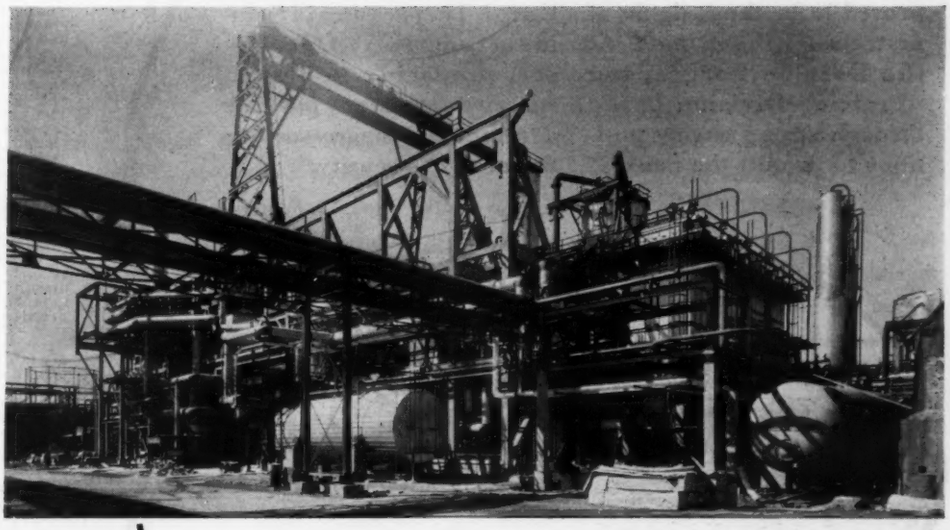

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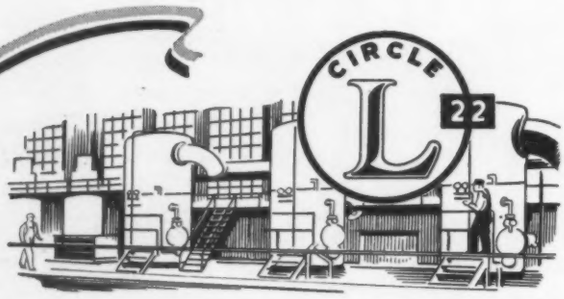

"DECISIVE BATTLES" in many a defense industry are those fought against corrosion of vital equipment. In these combats, the symbol of Lebanon's Circle L 22 has become known as the insignia of sure protection. This 18 and 8 stainless alloy is used to resist acetic acid, alkaline liquors, ferrous sulphate, sodium sulphate, hydrogen sulphide at normal temperatures. Circle L 22 meets U. S. Navy requirements when a carbon maximum of .07 is specified. This low carbon content is made possible by melting in Lebanon's induction furnaces.

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LEBANON *Stainless and Special Alloy* STEEL CASTINGS

much better yields of phenols than did platinum, which converted cyclohexanols to aromatic hydrocarbons.

The Use of Sulfuric Acid in Purifying Saturated Hydrocarbons: Its Action on 2,2,4-Trimethylpentane, F. C. WHITMORE AND H. H. JOHNSON, JR., *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1481-2.

The use of sulfuric acid as a wash in the purification of saturated hydrocarbons is widespread. Observation by the authors led them to believe that such treatment is questionable. The action of cold concentrated sulfuric acid on isooctane was studied. After treatment for ten days with cold 95% acid, half of the starting material had been changed to other products. The extent to which reaction takes place makes imperative a most careful fractionation of a saturated hydrocarbon following a sulfuric acid wash.

Manufacture: Processes And Plant

Sulphuric Acid from Refinery Sludge, A Chem. & Met. Pictured Flowsheet, *Chem. & Met. Engr.* **48** (1941) pp. 144-5 to 147-5.

Prior to the development of the Chemico sludge conversion process, acid sludges were hydrolized with water and steam to effect a separation into oil and weak acid after which the acid was concentrated for reuse. This method was wasteful and unsatisfactory because the separation was never entirely complete, but resulted in an impure black separated acid that could not be concentrated to the high strength necessary for some uses. An entirely different principle of recovery is now in use. The acid sludge is heated to about 550° F. when it decomposes into sulphur dioxide gas, solid coke, water vapor and a small quantity of hydrocarbon vapor. The advantage of this method is immediately obvious since the sulphur dioxide gas can be processed into a contact sulphuric acid of any desired strength. A flow diagram of the latest practice, based on a plant recently erected at the Bayway refinery of the Standard Oil Company of New Jersey, is given. The process as originally developed called for the use of hot combustion gases to heat the sludge by direct contact. A novel and more satisfactory method is now employed. The granular coke resulting from the decomposition of the acid sludge is fed in regulated quantity into a rotary kiln where it is ignited and discharged at red heat into a second and smaller kiln by means of a sealed plunger feeder. The heat content of the coke is transferred to the sludge which is fed into this second kiln in a measured and continuous stream and the breakdown reaction is quickly completed. The strong gas from the decomposition kiln is cooled to condense the moisture and condensable oil and then passed through a furnace where any fixed non-condensable hydrocarbon gases are burned. The gas is then cooled, dried and processed in a modern contact acid plant using vanadium catalyst. The coke from the decomposition of the sludge leaves the decomposing kiln with the circulating coke and is returned to the heating kiln after the excess has been diverted for use elsewhere as fuel.

Batch Fractionation, A. ROSE, *Ind. & Eng. Chem.* **33** (1941) pp. 594-7.

For mixtures of similar normal liquids with normal vapor-liquid equilibrium relationships, and in cases where the usual simplifying assumptions of distillation and negligible holdup are justified, the equations,

$$n = \frac{2.85}{\log_{10}\alpha} = R \text{ and } n = \frac{T_B + T_A}{3(T_B - T_A)} = R$$

are suggested for estimating approximately the equivalent number of theoretical plates, n, and reflux ratio, R, required for a standard separation in which the first 40 percent distilled has an average purity of 95 mole percent. The derivation of the equations is described, the limitations of such approximation formulas are emphasized, and they are compared with a correlation of more complicated Rayleigh equation calculations which show that the number of plates required may be chosen from any value within a limited range, provided the accompanying reflux is properly fixed. The limits of the range of n and the methods of choosing the proper reflux are indicated.

Calculation of the Effect of Reflux Ratio in Batch Fractionation, A. ROSE AND H. H. LONG, *Ind. & Eng. Chem.* 33 (1941) pp. 684-7.

Reflux ratio is one of the important variables in batch fractionation because of its relation to the sharpness of separation and to the time and expense required for collection of a given quantity of product of desired purity. The effect of reflux ratio in batch fractionation may be estimated by calculating

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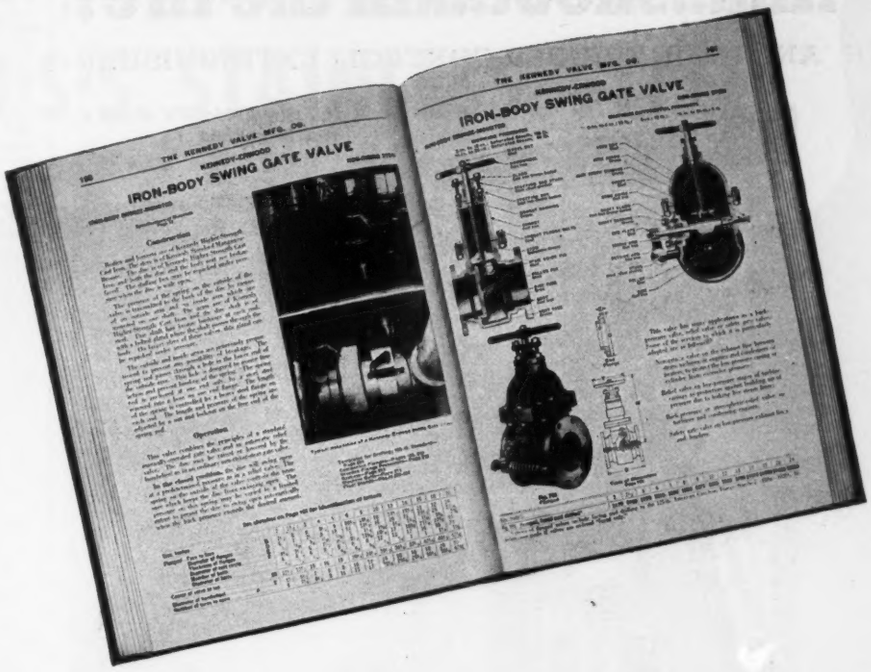
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distillation curves for the cases of interest by an extension of the methods of Young and Rayleigh. The paper summarizes the results of calculations of this type.

A Technical Review of the Industrial Recovery of Vapours by Absorbent Solids and in Particular Active Carbon, A. BERTRAND, *Chem. & Ind.* **60** (1941) pp. 171-5.

For the recovery of soluble vapours contained in air or other gas the following methods have been utilized: (1) condensation; (2) washing; (3) the use of absorbent solids. The first two methods are very briefly described. The article is mainly concerned with the third method. Two absorbent solids are industrially applied on a large scale. The first and most important is active carbon, and the second is silica gel. Active carbon is used in most recovery processes. The theory of the process is briefly considered. The energy of absorption of various substances and solvents is given. The process is considered specially applicable to the extraction of natural gasoline. Data are given on the weights of various substances as absorbed by 100 grams of active carbon in equilibrium with the gas mixture in which the absorbable vapour exercises a partial pressure between 8 and 9 percent of the saturation pressure. The desorption of the active carbon is described and discussed. Steam gives a more rapid and more complete desorption than air. The wax desorbed carbon is dried by passing air through it. Recovery through absorption is stated to be always higher than that which can be obtained practically in any other industrial process of condensation or absorption by washing. The efficiency of absorption of a well-designed carbon plant rarely falls below 95%. Absorption by active carbon can always be effected at concentrations of vapour in air below the lower explosive limit. The quantity of steam used for desorption varies between 2 and 5 pounds per pound of solvent recovered. The power requirement is limited to that required by the fan.

The Investigation of High-Boiling Petroleum Oils by Adsorption Analysis, B. C. ALLIBONE, *Jour. Inst. Petr.* **27** (1941) pp. 94-108.

The author describes the application of "chromatographic adsorption" to the analytical separation of the high-boiling components of petroleum. A distillation cut of restricted boiling range is dissolved in aromatic free petroleum ether, boiling point 60-80° C., and the solution filtered through a column of adsorbent. The adsorbent may advantageously be silica gel. After the addition and exhaustion of the primary solution, fresh petroleum ether is added to the top of the column and the filtration continued until the high-boiling material recovered from a unit of filtrate approaches a specific gravity of unity. The adsorbent is then drained by suction, removed from the column, and allowed to dry. The dried adsorbent is divided into suitable portions as its variation in color or other consideration may dictate, and extracted with a solvent or a succession of solvents. By these means, with variations to suit individual stocks, high-boiling cuts, whether distillates or residues, may be separated into a succession of components of widely varying physical characteristics. The application of the procedure and the degree of separation achieved are illustrated by means of selected examples. The analysis of pressable wax distillate is considered. The processing of a residual stock is illustrated by the data secured from the treatment of a crude residue containing both wax and hard asphalt. Adsorption analyses are given for Pennsylvania and Western bright stock. These stocks are characterized by substantial content of compounds of minimum specific gravity associated with a smaller content of compounds of intermediate specific gravity and high gravity resins present in variable amounts.

Products: Properties And Utilization

The Use of Mineral Oils as Mosquito Larvicides, H. D. LORD, *Jour. Inst. Petr.* **27** (1941) pp. 73-93.

A brief history of the researches on the use of mineral oils for anti-malarial work is first given. A summary of Murray's recent investigations follows; possibly the most important point made by him is that spreading pressure is all-important, and that toxicity is not nearly so crucial as had been previously believed. A description of the Adam-Langmuir apparatus for the measurement of surface pressure is given. This is used widely as a criterion of the quality of anti-malarial oils. The effects of storage, exposure to diffused and bright sunlight, and the addition of resin are described. The limitations of the Adam apparatus, and the care which must be exercised in interpreting the results obtained by its use, are illustrated, with special reference to a used naphthalene ex-

A neat job of lining a refinery tower with U·S·S STAINLESS STEEL

U·S·S 12 STAINLESS LINING *in a refinery tower head. This lining forms an effective barrier against high-temperature corrosion—adds years to the useful life of refinery vessels.*

WHEN one of our stainless steel refinery specialists sent in this photograph he said, "This is one of the best applications of stainless strip to refinery towers I have yet seen. It shows the bottom head of a vessel neatly lined with 4-inch strips of U·S·S Stainless Steel .078 inches thick."

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* * *

Because of the importance of U·S·S Stainless Steels in the National Defense Program, temporary delays in providing for normal peacetime requirements are unavoidable. We believe we can count on your understanding cooperation. Production facilities are being rapidly increased and inevitably we shall win this race against time and National need. U·S·S Stainless will then be more plentiful than ever before.

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ADAPTABLE. Techniques for lining any type of pressure vessel with U·S·S Stainless Steel have been worked out and proved in service by refinery equipment engineers. Lightweight stainless trays and caps of various designs have proved eminently practical in keeping towers on stream.

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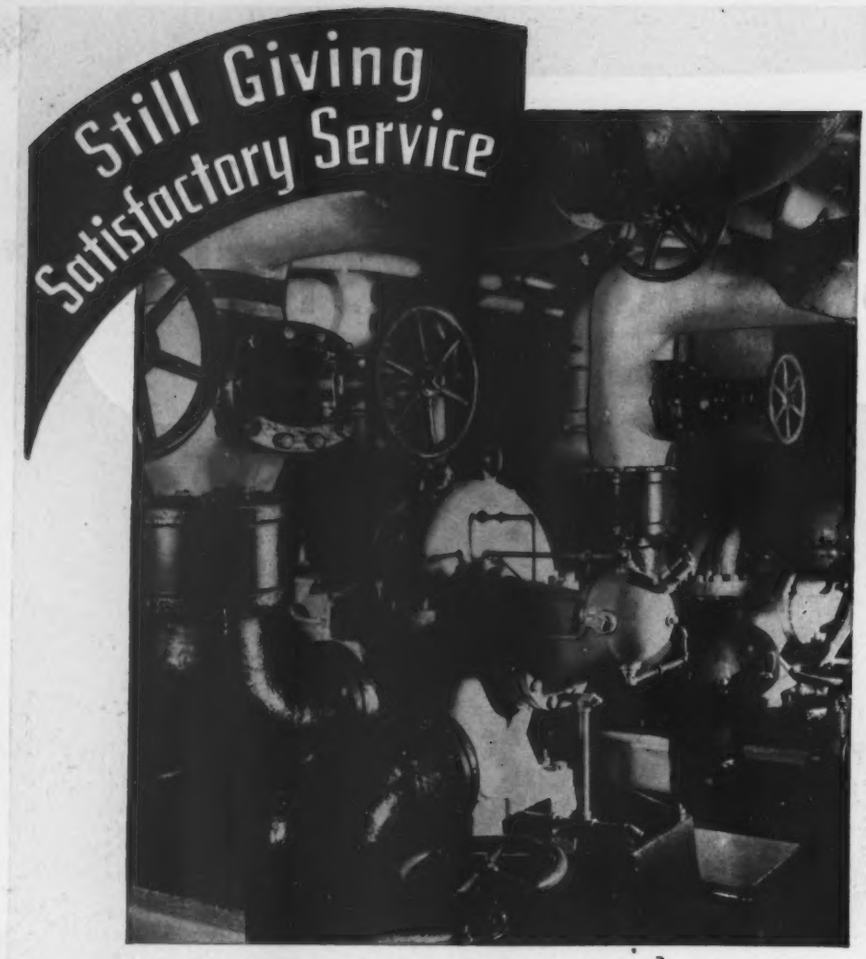

Fairbanks Iron Valves on House Service Pumps, Hotel New Yorker, New York

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traction oil. The essential requirements of a superior anti-malarial oil are considered. It is shown that a residue from pressure distillate fulfills these requirements. The entire subject is one of considerable importance in many countries. It has been estimated that in India alone over 1,125,000 deaths are caused annually from malaria, as well as a general deterioration in the health and lowering of the resistance to other diseases. Malignant fevers, as well as malaria, are carried by mosquitoes.

Indiana Stirring Oxidation Test for Lubricating Oils, G. G. LAMB, C. M. LOANE, AND J. W. GAYNOR, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 317-21.

The paper discusses a new laboratory testing technique that has been found valuable for predicting the oxidation stability of both inhibited and uninhibited crank case lubricating oils. An effort was made to investigate the outstanding conditions in an engine that would be expected to contribute to oil deterioration. The effect of metallic catalysts, of exposing thin films of oil above the oil level, of local high temperature, and aeration, were studied. It was observed that there is a great difference between blowing air through an oil and stirring air into an oil. This is the difficulty with the Indiana oxidation test and its lack of correlation with engine results. In the engine the gaseous products remain in contact with the oil because of the violent agitation, and hence in contact with metallic catalysts that promote oxidation and failure. The stirring technique was developed to simulate this action of the engine in maintaining the gaseous products in contact with the oil. The stirring test technique has also been found suitable for investigation of bearing corrosion, in all probability the cause of the more effective retention of corrosive volatile oxidation products. The authors state that their paper is not meant to bring forward a standardization or uniformly applicable laboratory test technique for the evaluation of the oxidation stability of lubricating oils, but that rather it means to emphasize the importance of a combination of several oxidation conditions that exist in engine operation, and which are believed to contribute largely toward the extent and nature of oil deterioration in the engine. Any successful laboratory test must provide for the effective retention of volatile oxidation products and contact of these products with metallic catalyst. It is believed that the essential features of the test may also be applicable to the evaluation of industrial oils, turbine oils, and other circulating oils.

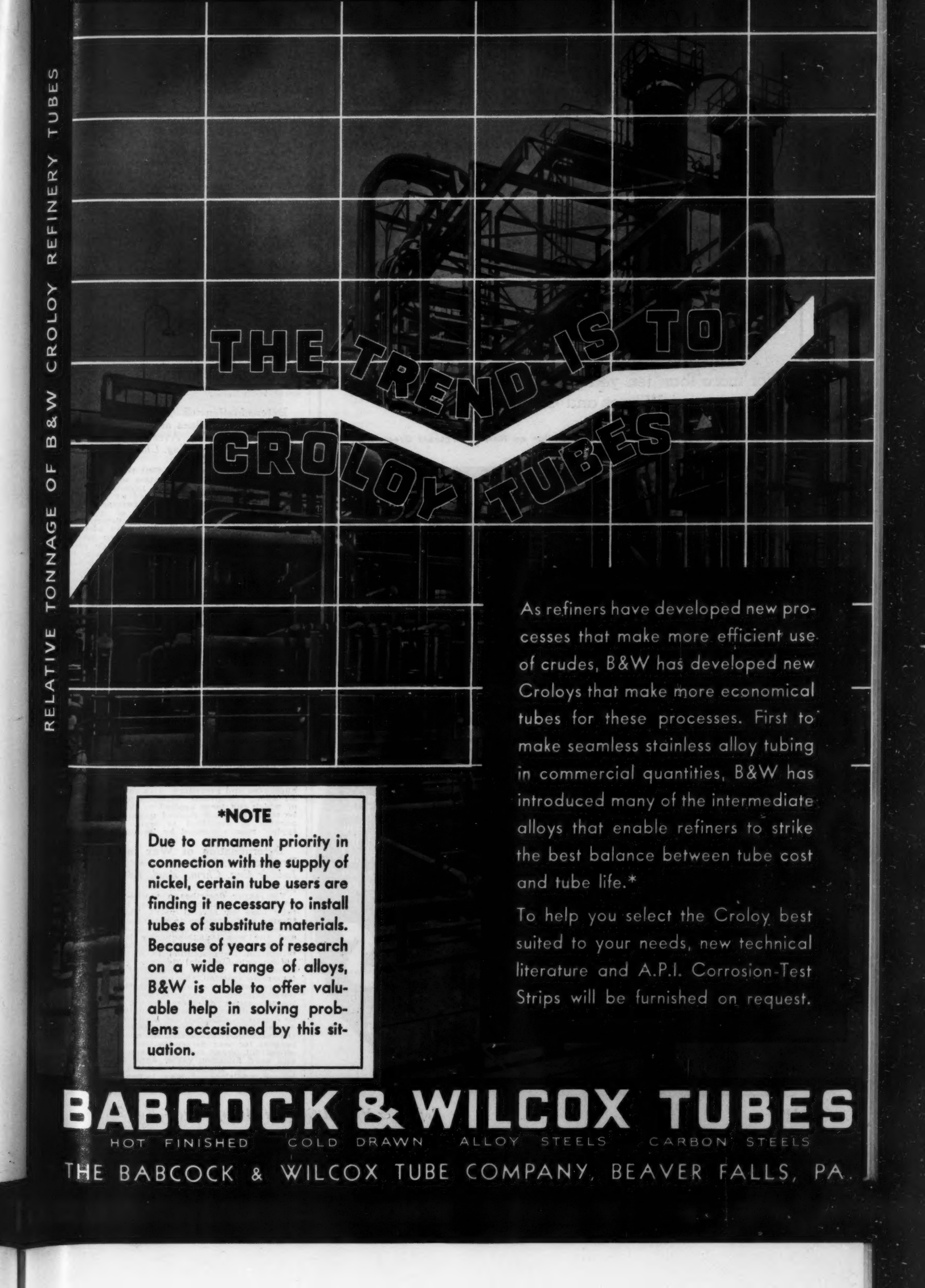
Evaluation and Performance of Turbine Oils, G. H. VON FUCHS, N. B. WILSON, AND K. R. EDLUND, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 306-12.

It is becoming increasingly recognized that the performance of lubricating oils in modern steam turbines is but slightly if at all predictable from the conventional tests upon which specifications are commonly based. In general, these tests exclude carelessly refined oils but make no distinctions as to the ultimate suitability of various well-refined products. Also, progress in the design and construction of steam turbines has introduced new problems in lubrication and aggravated old ones. Two essential requisites of a good turbine lubricant are the ability to protect steel surfaces against rusting and high stability toward oxidation. The tests described in the article are capable of revealing wide differences among turbine oils that meet conventional specifications. The chemical factors that influence the performance of oils in relation to the various methods employed by turbine operators to maintain an oil in serviceable condition are discussed. The turbine oil rusting test and the turbine oil stability test are described. The contamination of new oil in the turbine with used oil is considered, and the results in three typical cases are given. A bibliography of 37 references on the general subject is included.

Viscosity Measurement, M. R. CANNON AND M. R. FENSKE, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 299-300.

In a previous paper the authors described a simple and accurate viscometer for the measurement of the viscosities of liquids ranging from one third to more than one thousand times the viscosity of water. These instruments are now in wide use. The present paper describes a modification of this Ostwald viscometer which is particularly suited for measuring the viscosities of opaque liquids. It is also valuable for obtaining rate of shear-shearing stress data that are useful in studies relating to asphalts, wax crystallization, and oil flow properties at low temperatures. In addition, the transition region between viscous flow and plastic flow may be investigated with the viscometer described. Hence it should find application in the studying of plastic liquids in general. The viscometer is described in some detail. The instrument can be constructed to cover any desired range of viscosity. The usual instrument requires a charge of 13 cc. but it can be designed to

RELATIVE TONNAGE OF B&W CROLOY REFINERY TUBES



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take a charge of 5 cc. The authors believe that the viscometer will have great utility in connection with studies relating to dewaxing, wax crystallization, pour point depressors, low-temperature flow characteristics, and low-temperature storage of oil.

Quality Tests for Petroleum Solvent Naphthas, E. H. McArdle and E. L. Baldeschwieler, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 301-5.

Quality tests for petroleum solvent naphthas are discussed. Volatility is first considered. Some simple, inexpensive, and accurate method for evaporation rate has long been sought, and would doubtless be adopted if it were developed. In the meantime the A.S.T.M. distillation is still used. Solvency tests include the aniline point or the mixed aniline point, as used in the petroleum industry, kauri-butanol value, which was the earliest solvency test to be accepted by the paint and varnish industry, the dilution ratio test, using the nitrocellulose dilution ratio, and other dilution tests employing synthetic resins. Physical properties that rate solvency, and which are deemed important, include gravity, viscosity, refractive index, and surface tension. Solvency can be rated in terms of composition, i.e., in terms of a naphtha's content of paraffin, naphthene, and aromatic hydrocarbons. Relationship of volatility and solvency is discussed at some length. The authors believe that as a replacement for other laboratory solvency test the kauri-butanol value, which provides a linear, or nearly linear correlation of solvency for products of similar evaporation rate is the best. Materials required are inexpensive, and the time is short. A bibliography of 45 references is included.

Determination of Mercaptan Sulfur Content of Gasolines and Naphthas, H. Schindler, G. W. Ayers, and L. M. Henderson, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 326-8.

The authors have found that the results of mercaptan sulfur determination are too low when elementary sulfur is present in the gasoline, and has been removed as mercuric sulfide. They have found, furthermore, that the mercaptan sulfur content of gasoline or naphtha can be quantitatively determined by the Borgstrom and Reid method without previous removal of any elementary sulfur that may be present. Tests were made with solutions containing several mercaptans in Stoddard solvent. Certain of the mercaptans are absorbed by mercuric sulfide, resulting in such cases in low values for the mercaptan sulfur content of the naphtha that has been agitated with mercuric sulfide. Several tables of typical data are presented to illustrate the points made in the paper.

Consistency Test for Lubricating Greases, H. Levin and C. J. Schlagel, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 295-7.

The testing method described in the paper has been developed and used as an extension of the A.S.T.M. method for greases too soft for the standard A.S.T.M. procedure. The stated scope of the A.S.T.M. method, measuring the unworked or worked consistency of lubricating greases that have a worked consistency of less than 400, generally limits the use of the method to greases softer than No. 0 cup grease. Greases much softer than this are regularly manufactured for lubricating washing machines, mine car journal bearings, rail curves, and the like. The proposed method of test involves the standard A.S.T.M. apparatus and procedure, with the addition of an easily removable attachment by means of which the force applied to the grease can be reduced to any desired quantity. The apparatus is described in some detail, and typical results secured by its use are given.

Determination of Wax in Asphaltic Products, E. C. Knowles and H. Levin, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 314-17.

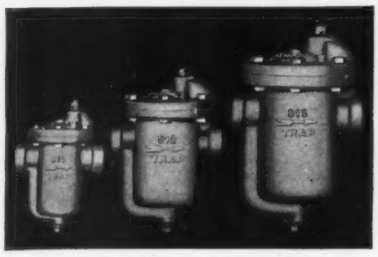
The paper describes a method for determining wax in asphalt that has been successfully used for several years. The asphalt is treated with propane to separate the asphaltene-resin fraction from the oil-wax fraction, and the wax is subsequently isolated from the oil-wax fraction by low-temperature crystallization from solution in methyl isobutyl ketone, or commercial Hexone. Propane treatment effects a clean removal of the asphaltene-resin fraction, the presence of which interferes with crystallization methods for the determination of wax. It avoids the detrimental effect of more drastic treatments, such as digestion with strong sulfuric acid or destructive distillation, both of which may destroy some of the wax. Hexone possesses the necessary properties of an outstanding reagent for wax determination—namely high oil-solvent power and low wax-solvent power, and good filtration rates. Application of the method to asphaltic samples containing known additions of wax indicate that the method is accurate.

New Equipment for the Modern Plant

Steam Traps

ARMSTRONG MACHINE WORKS

Side inlet steam traps designed for 800 - 1000, 1600 - 2000 and 3000 - 4000 pounds-per-hour capacity range, designated Models 811, 812 and 813, have been announced by Armstrong Machine Works, Three Rivers, Michigan. They are built for operation on pressures up to 250 pounds.



Armstrong Machine's Steam Traps

The traps are designed so trap cap carrying mechanism can be removed without disturbing pipe connections; so trap body may be left permanently in the line to obviate any necessity of handling a vessel filled with hot condensate or having to reprime the trap, and so that horizontal, straight-through pipe connections can be employed.

The traps are equipped with stainless steel inverted bucket operating mechanism, and are available with the blast-type thermic air vent buckets and internal type check valves as optional extra equipment.

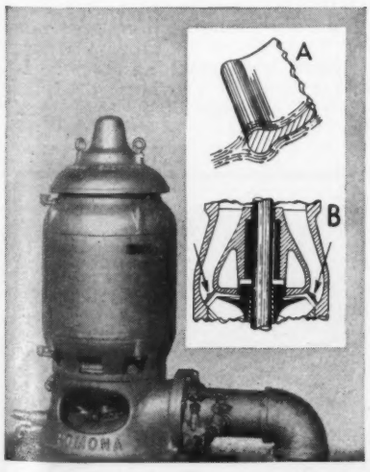
Pump

POMONA PUMP COMPANY

Design improvements to eliminate hydraulic losses in pumps, involving changes in guide vanes which alter from horizontal to vertical the flow direction of fluids being pumped, have been announced by Pomona Pump Company, St. Louis.

Advanced vane ends are formed in a bulbous shape to provide that, regardless of the flow direction of the fluid, its direction will always be substantially tangential to the vane surface. The change from guide vanes formerly constructed as thin as possible on the theory that the less metal the fluid strikes, the less is the resistance, is designed to secure greater uniformity of flow pattern, reduce friction, increase fluid lift efficiency, and to eliminate formation of eddy currents.

The new guide vanes are an inherent part of the pump bowl assembly, and the new design may be employed merely by substituting a new bowl assembly in present pumps of the manufacturer.



Pomona vertical pump equipped with new guide vanes. Insert A shows bulbous shaped end of guide vane; insert B shows cross-section of bowl assembly.

Transformer

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

A 1200-volt current transformer designed for low voltage, outdoor metering service has been announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. It is the first unit of its kind available at a rating below 5000 volts.

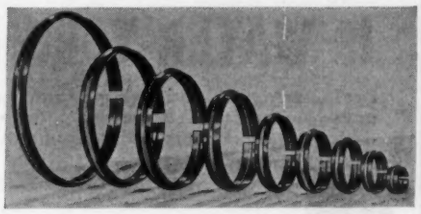
Known as the WO-1 dry-type-current transformer, it has three ratings, 200/5, 400/5 and 600/5 amperes. It is designed to permit long-range accuracy, being rated for 150 percent normal current continuous operation without exceeding 55° C. rise with a 40° C. ambient. Mechanical strength against instantaneous overcurrent is rated 250 times normal current R.M.S. first peak and thermal capacity of the windings will permit 70 times normal current for one second.

End frames of the transformer completely surround the wound-type coils to brace them against disruptive effects of short circuit current. The transformer is enclosed in a welded steel case.

Welding Rings

TUBE-TURNS, INC.

Welding rings designed to automatically line up and space welding ends of fittings or pipe, eliminating need of clamp and fixtures, have been announced by Tube-Turns, Inc., 224 East Broadway, Louisville, Kentucky. They may be used with all types of welding fittings and pipe joints, including elbows, tees, reducers, caps, and welding neck flanges, and with straight pipe.



Tube-Turns' Welding Rings

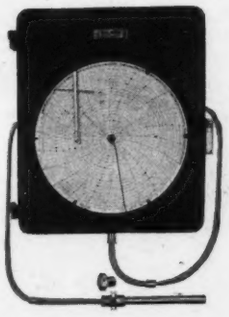
In use, the operator applies enough heat to melt down and puddle the ridge of the ring thoroughly to get full penetration to the bottom of the pipe wall without danger of slag or icicles being formed inside the joint.

Use of the rings is designed to reduce the amount of rod metal used.

Filter

MORAINE PRODUCTS DIVISION

A porous metal product designed to remove foreign materials from fluids, and to alter characteristics of gases by diffusion, reducing pressures and controlling flow rates, designated Porex, has been announced by Moraine Products Division, General Motors Corporation, Dayton, Ohio. It is made from



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powdered metal subjected to a series of processing operations.

Physical characteristics, including chemical composition, structure, porosity, strength and ductility, may be varied within limits to suit specific applications, and similar variations may be accomplished in size and shape. Standard shapes now available are discs, sheets, cylinders and truncated cones. Special shapes are obtainable.

Porex may be bonded to steel and copper, thereby being made an integral part of solid metal which may be machined, ground, bored, threaded or processed for individual requirements.

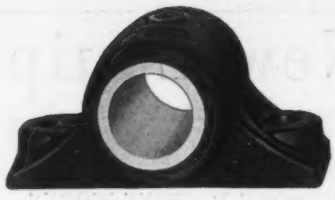
Used as a filter, it is designed to permit high flow rates, low flow restriction and a high degree of surface clogging before efficiency is reduced. As a diffusing plate, it is designed for low flow restriction and uniform, controlled porosity.

Bearing

THE JEFFREY MANUFACTURING COMPANY

A line of solid and split journal bearings stocked, cased and labeled for prompt delivery, has been announced by The Jeffrey Manufacturing Company, Columbus, Ohio.

Of gun-metal finish, the bearings have machined bases and faced ends. Babbitted bores are broached to smooth hard surface to require no wearing in. They are tapped for grease cups or pressure fittings, with a storage groove in the top to provide proper distribution of lubricant. The split bearing has feeder grooves on each side.



Jeffrey Manufacturing Bearing

Paint

THE WILBUR & WILLIAMS COMPANY

A paint designed to reflect light, designated light gray Totrust, has been announced by The Wilbur & Williams Company, Park Square Building, Boston.

The paint employs an oil vehicle to penetrate pin holes and rusted pits in the metal and expel moisture that may be present. It may be used over galvanized metals, and is available in colors in addition to gray.

One gallon covers 800 to 1200 square feet, and the paint is not affected by a temperature range from 100° F. below zero to 800° F. above zero.

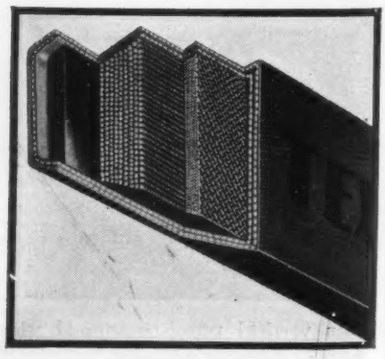
V-Belt

ALLIS-CHALMERS MANUFACTURING COMPANY

A line of V-belts based on the Vogt formula, designated Super 7, has been announced by Allis-Chalmers Manufacturing Company, Milwaukee.

The belt employs small cords, permitting use of a larger number to provide greater strength with less stretch. Cords are imbeded in heat-dissipating rubber to reduce internal belt degeneration.

The belts are made in matched sets to provide uniform, smooth-running efficient drives. Live-rubber bottom is designed to absorb impacts of operation; central cord portion to transmit power at the effective pitch diameter; and bias cut fabric to provide transverse stability. Two-ply rubber-impregnated fabric cover is designed to prevent destructive agents from reaching the vital belt elements, and to provide a high grip coefficient between belt and sheave walls.



Allis-Chalmers Super 7 V-Belt

IS WATER YOUR ENEMY OR ALLY?

Scale, corrosion and living organisms can sabotage your plant, cause expensive shut downs, reduce production, create need for difficult replacements and consume many man-hours badly needed in production.

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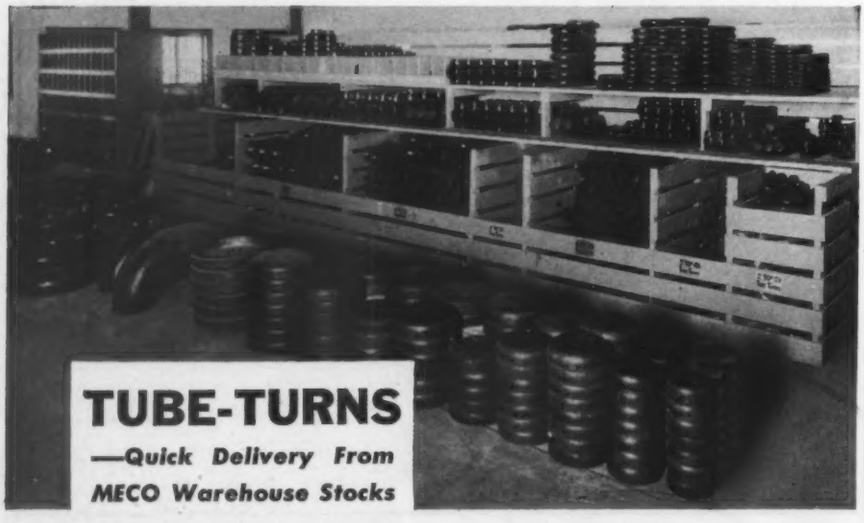

TUBE-TURNS

—Quick Delivery From MECO Warehouse Stocks

Pictured above is a part of our TUBE-TURN Stocks. Top row of bin shows welding reducers, tees and 180° TUBE-TURNS. Middle row of bin shows 45° TUBE-TURNS and welding tees. Bottom row of bin shows 90° Standard TUBE-TURNS. Row in foreground shows welding heads and 180° TUBE-TURNS. Available in standard, extra heavy and double extra heavy patterns.

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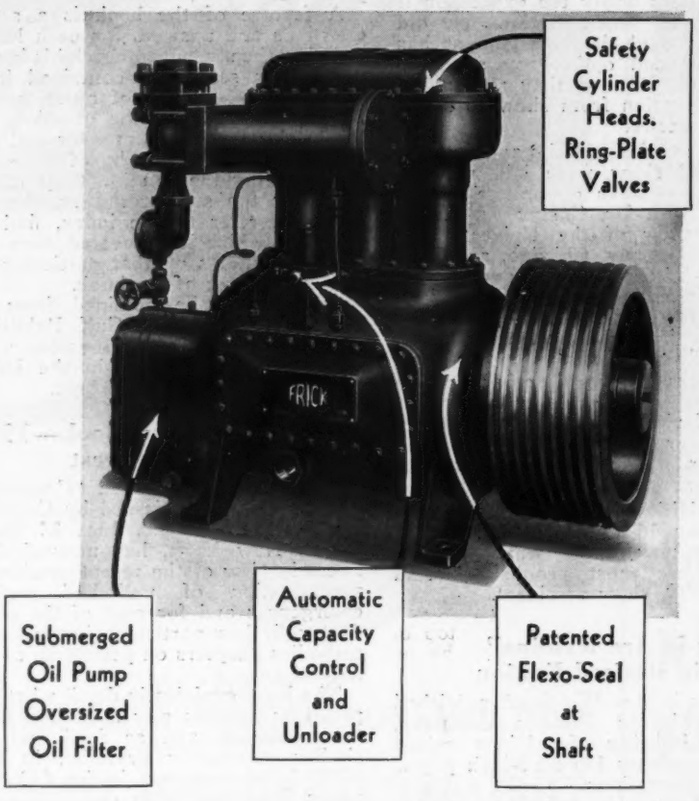
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BUSINESS NOTES

Bantam Bearings Heads Exposition Paid-Up Exhibitors

Bantam Bearings Corporation, South Bend, Indiana, is the first exhibitor of the International Petroleum Exposition in Tulsa to send in a check in full for space for the 1942 show, scheduled for May 16 to 23, according to General Manager William B. Way.

Formal contracts were mailed to 126 companies which have requested more than 58 percent of the available space in the 30-acre plant of the oil show, Way said.

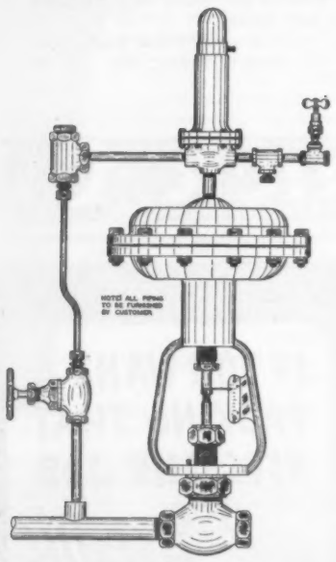
Firms which have made requests for new or increased space total 78, and will be sent contracts as soon as all 1940 exhibitors notify the exposition if they wish to renew options on old space. Way said the management has always extended options on space to oil-show exhibitors so they may retain the same location from show to show, if they so desire.

Initial plans for exhibits and features at the 1942 show were laid recently when the executive committee of the show met with Dr. Gustav Egloff, research director of the Universal Oil Products Company, Chicago, and head of the exposition scientific and technical committee, and Dr. B. B. Weatherby, Amerada Petroleum Corporation, Tulsa, who is working with Egloff on the scientific exhibits.

"The present world crisis, which places petroleum almost at the top of the list of vital necessities, will be responsible for the most elaborate and complete scientific displays ever seen at the oil show," Egloff said.

"All activities for promoting a successful May 16 to 23, 1942, show in Tulsa are now under way, and the prospects are most promising," said W. G. Skelly, show president.

H-W Type 1523
Pilot Operated Regulator for Field Pressure Control



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"Lessons In Arc Welding" Offered in Revised Edition

"Lessons in Arc Welding," published by The Lincoln Electric Company, Cleveland, is being offered in a revised edition containing 176 6 x 9-inch pages, with 170 illustrations.

Helpful to beginners learning to arc weld, to experienced welders desiring practical information, and to welding officials, such as supervisors, foremen and instructors, as well as others interested in the subject, the book comprises a ready reference on arc welding and a guide to its proper application.

The book is a series of 60 lessons which present, in concise manner, fundamental facts of welding, knowledge of which will enable the welder to utilize the process successfully and economically. It includes an introduction giving preliminary instruction to the welder, embracing suggestions for making and following a definite plan for learning the fundamental principles of arc welding, and for practicing continually, examining welds, criticizing and inviting criticism of work, for wearing proper protective apparel at all times, and assuming proper working positions.

A feature of the book is a set of questions and answers for each lesson, enabling the student to check his knowledge. This section is contained in 25 pages, with 18 pages of questions and 7 of answers. Since the questions are headed by the lesson number and subject matter, they can be of assistance in furnishing the solution to problems. Knowing the subject matter, the student can refer to the index, find the lesson in which it is covered, then turn to the questions on that particular lesson in the back of the book.

Copies may be obtained from the Book Department of Gulf Publishing Company, Box 2608, Houston, at 50 cents a copy, postpaid in the United States, and 75 cents elsewhere.

"Commodity Year Book—1941" Is of Timely Oil Interest

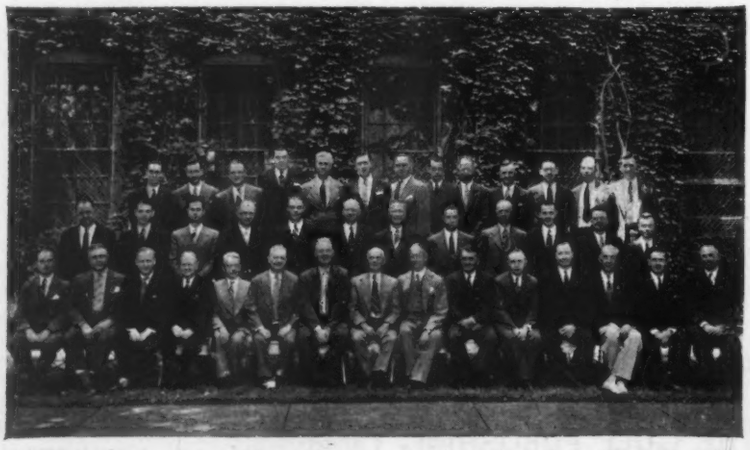
The recently published "Commodity Year Book—1941," issued by Commodity Research Bureau, Inc., 82 Beaver Street, New York, has unusual timeliness in view of the recent presidential proclamation of unlimited national emergency; and for men of the oil industry, it has particular interest as it embodies chapters on petroleum and on natural gas.

The book explains in detail what happened as regards raw materials, labor, transportation, and so forth, when a similar emergency prevailed in 1917-1918. It also shows, in its 650 large pages, illustrated with charts and containing many tables, how the 1941 pattern of events is closely following the World War period.

Listed among future developments to expect are stricter rationing of raw materials, a tightening of control of labor, capital, production facilities transportation and fuel supplies.

F. H. Payne, American Meter Head, Completes 50 Years

Francis H. Payne, president of American Meter Company, New York, was honored June 20 at a surprise testimonial at the Kahkwa Club, Erie, Pennsylvania, tendered by 46 officers and members of the company's factories and sales offices throughout the country. The event marked Payne's fiftieth anni-



Officials of American Meter Company gathered at Erie, Pennsylvania, recently to honor Francis H. Payne, president, on completion of 50 years with the company and manager of its Metric Metal Works.

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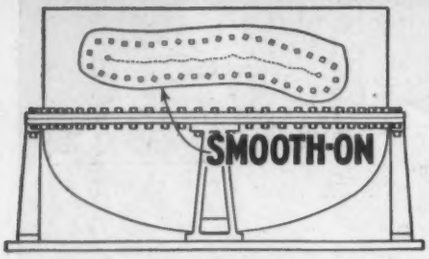

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versary with the company, during which period he has been manager of its Metric Metal Works. He was given an antique grandfather's clock, the presentation being made by Norton McKean, company vice president and manager of its D. McDonald & Company works in Albany, New York.

Payne's father, the late Calvin H. Payne, was engaged in oil development in Pennsylvania, and built the first natural gas pipe line in America. Francis Payne entered the gas meter business in 1891, when he became secretary and manager of Metric Metal Company, Beaver Falls, Pennsylvania. In the same year, the company built a new factory at Erie, transferring its entire organization. Payne was elected a vice president of American Meter Company in 1923, and was made president in 1936.

"Air and Gas Compression" Details Present-Day Practice

Results of recent researches in properties of gases, especially in regard to compressibility, critical data and specific heats, are covered in "Air and Gas Compression," by Thomas T. Gill, Union Oil Company of California.

It makes available specific information on practical applications of theories of compression and gas measurement, particularly with reference to technical details. The author has selected and presented data most needed by those whose work deals with air and gas compression.

The book includes a chapter on flow of gas in pipe lines, based on the Weymouth equation. Included also is series of tables designed to reduce the labor required in computing pressure drop in pipe lines. The solution of problems is based on equations, tables and alignment charts, an arrangement that enables the reader to check nearly all computations in several different ways.

The volume includes 181 pages, 6 x 9 inches, and 35 illustrations. Copies may be obtained from The Gulf Publishing Company, Drawer 2608, Houston, at $3 a copy.

Supply Personals

Laurence M. Ewell, export manager for Link-Belt Company, Chicago, has been named general manager of the company's eastern division operations, with headquarters in Philadelphia. He is succeeded as export manager by Carl A. Woerwag, former assistant export manager.

Ewell entered the employ of the company in Philadelphia in 1906, and advanced successively through the drafting

L. M. Ewell

C. A. Woerwag

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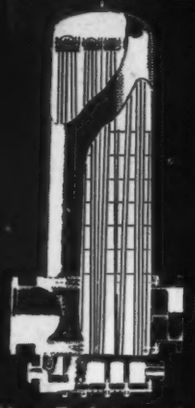

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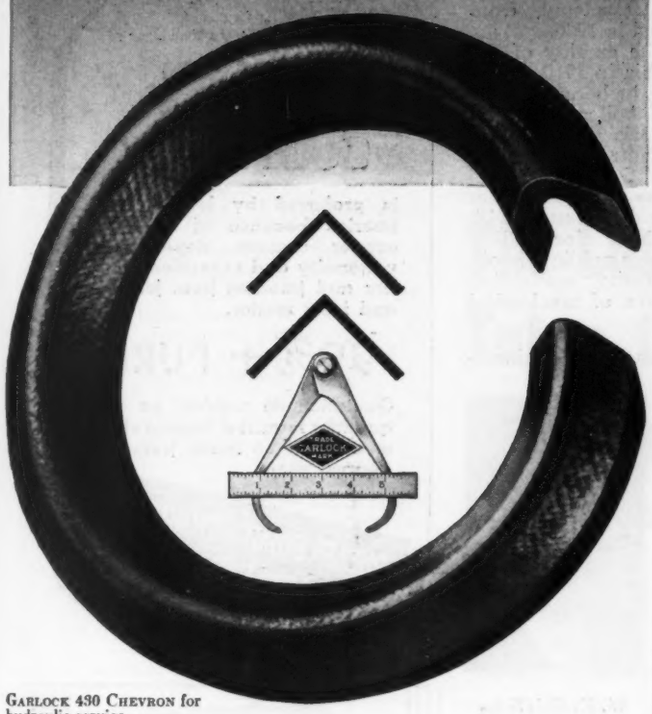

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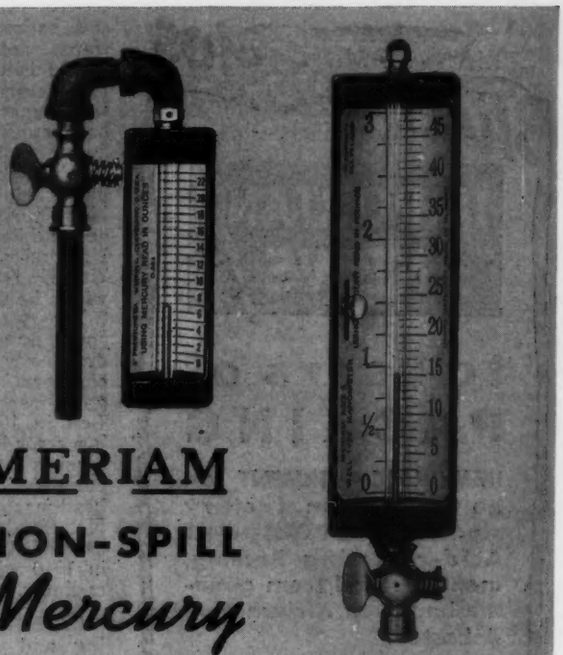

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● These are accurate, compact direct reading gauges for measuring small air and gas pressures. The 3 inch size shown at the left, measures to 22 ounces, is 1¼″ wide, 1½″ deep, 5½″ high and weighs 20 ounces. The 6 inch size shown at the right, measures to 3lbs. or 48 ounces, is 2″ wide, 1¾″ deep, 9½″ high and weighs 1½ lbs. Both are provided with a heavy walled Pyrex glass tube, protected on three sides with a strong semi-steel cast housing finished in dull black baked on Japan.

Both sizes — because the mercury cannot spill out—are widely used by service men as a portable gauge for testing air lines, fuel lines, etc., and due to their low price have found wide use for permanent installations in industrial plants. Bulletin No. 3 gives complete details. Send for a copy.

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and estimating departments. He was transferred to the sales department; sent to the Pittsburgh office in 1911, and in 1915 returned to the Philadelphia plant sales department. Since that time, he has been constantly employed in the sales department, variously as sales engineer and branch manager of Link-Belt offices in Philadelphia, Chicago, St. Louis and New York. He was educated in private and public schools in Baltimore, at the University of Maryland, and at the United States Naval Academy, from which he was graduated in 1906.

Woerwag entered the employ of the company at Philadelphia in 1910, in the drafting room. In 1914, he became squad engineer in charge of boiler plant and gas house conveyor work. He left Link-Belt in 1917 and became an ordnance inspector in the United States Army, returning to the company in 1919 as sales engineer in the export department, with headquarters at the New York office. He attended Philadelphia public schools, entered Lehigh University, graduating in 1910 with the degree of mechanical engineer.

W. E. Griffiths, engaged in engineering and sales promotion of stainless and other alloys for Carnegie - Illinois Steel Company in the Mid-Western states, has been named manager of a new development engineering department of Allegheny Ludlum Steel Corporation, Pittsburgh. Eighteen years ago he started as a metallurgist with Union Carbide and Carbon Research Laboratories specializing in stainless alloys, and later held metallurgical positions with Duraloy Company and the central alloy division of Republic Steel Corporation.

W. E. Griffiths

W. F. Detwiler, Jr.

W. F. Detwiler, Jr., assistant manager of the department, started in 1936 in the metallurgical department of the company's silicon steel division, spent part of 1939 in Sheffield, England, as European representative, and since his return has been engaged in warehouse control at the Pittsburgh headquarters offices.

S. D. Distelhorst, sales promotion manager of Cochrane Corporation, Philadelphia, has been awarded a professional engineering degree by Purdue University. He graduated from Purdue in 1935 with a bachelor of science degree in electrical engineering. His thesis was titled "A Practical Advertising and Sales Promotion Plan for Cochrane Corporation."

James A. Trail has joined the Hyatt Bearings Division, General Motors Sales Corporation. For several years, Trail has been an associate professor in mechanical engineering at the A. & M. College of Texas. He will cover the Southwest territory, traveling out of

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Dallas. A. J. Swisler, who formerly handled this territory, will work out of western division headquarters in Chicago.

John H. Heinzerling has joined Vinson Supply Company, Tulsa, to work on sales, service and installation of Fisher Governor Company's Control equipment. Former research engineer in the Port Arthur refinery of The Texas Company, Heinzerling has spent six years in the Dallas office of an instrument company. He will make his headquarters at Tulsa.

J. H. Heinzerling

J. M. Howell, executive assistant to E. D. Spicer, manager of the Schenectady works of General Electric Company, has been named to succeed his chief, who has been advanced to the post of assistant to the vice president in charge of manufacturing. Howell started with General Electric nearly 40 years ago, when he was engaged as a shop clerk in the old switchboard department. In 1905, he transferred to the cost department. He was appointed assistant section head of the department in August, 1906, and head of turbine costs in December of the same year. In February, 1909, he was named head of turbine and control cost department, and was appointed chief cost accountant for the works in July, 1920. In September, 1923, Howell was appointed works accountant, and in 1937 became executive assistant to Spicer.

George T. Kilmon has been elected assistant secretary, and Edward M. Martin, assistant treasurer of The B. F. Goodrich Company, Akron, Ohio. Kilmon, member of the company's legal staff for 16 years, will fill a vacancy caused by the death of J. L. McKnight, and will be in charge of the company's law department. He joined the company in July, 1925, following graduation from the University of Virginia. Martin, who returned to the United States from France on April 15, joined the company in February, 1920, as a member of the Akron credit department, later going to Toledo, Atlanta and New York City in managerial capacities for this department. In 1931, he was assigned to duties in Europe, Africa and the Near East, remaining abroad, except for short business trips to the United States, until his return last month. He is a graduate of Harvard University.

W. L. Schneider, sales manager for The Falk Corporation, Milwaukee, has been elected vice president in charge of sales. A 1925 graduate of Marquette University, he started with the company as sales estimator, and successively held positions as sales engineer, assistant sales manager and sales manager.

T. F. Scannell, assistant to the sales manager, succeeds Schneider as sales manager. A 1918 Yale University graduate, he served as an ensign in the Navy during World War I, was with Chain Belt Company, and joined Falk in 1928 as St. Louis representative. He later was southwest district manager, and since April, 1940, has been assistant sales manager.

Wesley Fisher has been named sales representative by Briggs Clarifier Company to work with The Continental Supply Company in promoting sales in the Mid-Continent area. Fisher, who has had 12 years experience with oil clarifying and filtering equipment, with special attention to lubricating problems, will make his headquarters in Houston.

Wesley Fisher

J. B. Kelley, in charge of Falk's flexible coupling business, has been named assistant to the sales manager. Since graduating from Marquette University in 1927, he has been with Falk, first as an apprentice and later as an estimator, saelsman and district manager at Cincinnati.

Myron Powers, in charge of purchases at the Cleveland plant of Chicago Pneumatic Tool Company, has been named manager of purchases, with headquarters at the general offices in New York.

C. M. Maratta, maintenance engineer since 1921 for The Timken Roller Bearing Company, Canton, Ohio, has been appointed Chief Works Engineer to fill

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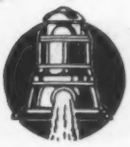

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Layne-Western Co.	Kansas City, Mo.
Layne-Western Co. of Minnesota	Minneapolis, Minn.
Layne-Bowler New England Corp.	Boston, Mass.
International Water Supply	London, Ontario, Can.

a vacancy left by death of W. C. Makley. Maratta served as power plant inspector of the Pennsylvania Railroad for seven years, draftsman for Westinghouse Electric & Manufacturing Company for four years, and joined Timken as a draftsman in 1917.

Walter F. Green, who has been with the Timken engineering department since 1935, becomes Assistant Works Engineer, and Putney L. Wright, with Timken since 1938, will be plant engineer.

E. S. Bissell has been made vice president of Mixing Equipment Company, Rochester, New York. He had been technical sales manager. Joining the company in 1937 as sales manager, within a few months he was also appointed director of research, and assumed the responsibilities of development and market study. Before his association with Mixing Equipment, he was assistant to the manager of instrument sales, Bausch & Lomb Optical Company.

Bissell is a graduate of Kansas State Teachers College, holding a B. S. degree.

C. G. Tyler, formerly with the railroad division of Manning, Maxwell & Moore, Inc., in the Chicago district, has joined the industrial division to take over the territory served from Columbus, Ohio. This district was formerly covered by Win Adams, who has been transferred to the Buffalo territory. Arthur B. Bleecker, formerly with the Los Angeles Branch of Creamery Manufacturing Company, will represent four of the company's industrial divisions in the Pacific northwest, covering the Seattle and Portland territories.

W. C. Pinkerton, for the past six years assistant technical editor of Chemical Engineering Catalog, has resigned to join the monel and rolled nickel advertising department of The International Nickel Company. He will edit house publications devoted to those industries.

Harry C. Merriam, 56, member of the board of directors of E. B. Badger & Sons Company, died June 27 in Newton, Massachusetts. He became associated with the Badger company late in 1917 as a member of its chemical engineering sales division.

Carl D. McWade, advertising manager for the Continental Supply Company, Dallas, has started a year's military service. His duties with the company are being assumed by A. J. Mueller.

William F. Crawford, associated with The Edward Valve & Manufacturing Company, East Chicago, Indiana, since 1931, has been named president of the company. Previously in active charge of manufacturing, research, advertising and sales promotion activities, he succeeds W. W. Crawford, who died earlier this year.

W. F. Crawford

Stanley A. McCaskey has been elected assistant secretary of Allegheny Ludlum Steel Corporation, Pittsburgh. A native of Wilkinsburg, Pennsylvania, he is a 1931 graduate of Harvard Law School. McCaskey served with South Penn Oil Company, and later as vice president and general counsel of Six States Coal Corporation. He resigned to become chief counsel for the treasurer of the United States in Washington, and in 1938 went to San Juan as assistant general counsel for the Puerto Rico Reconstruction Administration. Returning to Washington in 1940 as assistant chief of the Foreign Funds Control Division of the Treasury Department, he resigned in September of that year to become associated with Allegheny Ludlum.

S. A. McCaskey

Herbert J. Braun, formerly with Foote Bros. Gear & Machine Corporation, Chicago, has been appointed Detroit sales representative for McKenna Metals Company, Latrobe, Pennsylvania, with headquarters at 14425 Mark Twain Avenue, Detroit.

Harry McCool, Jr., has been appointed southwestern sales representative for the Steel and Tube Division of The Timken Roller Bearing Company. His territory includes Kansas, Louisiana, Oklahoma, Arkansas and Texas, with headquarters at Dallas. McCool joined Timken in 1928 as hot mill operator, and was advanced to superintendent of the tube mill at Wooster, Ohio, in 1935. He served in this capacity until March, 1941, when he joined the sales department of the Steel and Tube Division.

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